FARMERS' RELATIONS WITH TREES IN THE MESOAMERICAN TROPICAL DRY FOREST: NARRATIVES AND REALITIES

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For my parents

and for Jackie, José and Rebecca

with love and thanks

Abstract

Farmers' Relations with Trees in the Mesoamerican Tropical Dry Forest: Narratives and Realities

Adrian Barrance

This essay reviews the results of research into relations between small farmers and trees in the Mesoamerican Tropical Dry Forest (MTDF), aimed at identifying relevant and workable strategies for tree management that would take into account global as well as local priorities, while respecting local livelihoods and tenure systems. The main aim of the essay is to review the contribution of the research to the overall field of knowledge regarding relations between small farmers and trees in the MTDF. To provide a framework for this discussion, it first reviews a series of narratives that have become dominant worldwide regarding relations between rural people and trees. The validity of each is then questioned in the case of the MTDF, on the basis of the results of the research. On the basis of this, the essay then discusses options for improving the processes whereby narratives regarding the MTDF are generated and influences policies and actions, in order better to serve its diverse stakeholders. Finally, it reflects on some priority issues that are likely to continue to pose significant challenges for researchers and practitioners in the MTDF in the future.

Narratives portraying farmers in the MTDF as culprits or victims of environmental degradation, or as active conservationists, all correspond to some extent with the research findings, but fail to take adequately into account the regenerative potential of MTDF trees, their conservation status, the nature of relations between farmers' livelihoods and natural resources, or the legal, policy and institutional frameworks determining farmers' actions. The essay argues that it is illusory to search for universal truths or perfect decision-making regarding such complex ecosystems and issues. Future priorities should include democratizing and broadening research, addressing inequitable power relations, balancing the interests of diverse stakeholders and developing capacities at all levels for adaptive management.

LIST OF CONTENTS

Section 1. Introduction 6
Aims and structure of the essay 6
Background to the research 6
Motivations of the research 7
The scope of the research 9
Conceptual framework 10
Section 2. Dominant Narratives of Smallholder/Tree Relations 12
The farmer as culprit 12
The farmer as victim 15
Poverty and environmental degradation 17
The farmer conservationist 20
Conclusions 23
Section 3. The Contribution of the Research 25
The status of the MTDF 25
The role of small farmers in deforestation 29
Tree husbandry by small farmers 31
Community-level natural resource management 34
Conservation through use 38
The relevance of poverty 41
Conclusions 43
Section 4. Improving Practice 46
Clarity and rigour in research 47
Broadening of research 48
Democratization of research 50
Improved communication and uptake of research findings 52
Translating research findings into action 53
Promoting local participation in conservation and development 55
Monitoring 57
Adaptive management 58
Conclusions 60
Section 5. Challenges for the future 62
Conclusions 65
References 67
Annex 1: Summary of published work 77
Annex 2: Supporting Publications 81

Abbreviations

CBNRM	Community-Based Natural Resource Management
CONSEFORH	'Conservation of Forestry Species in Honduras' Project
CTU	Conservation through Use
CUBOS	Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' Project
DFID	Department for International Development
MTDF	Mesoamerican Tropical Dry Forest
NGO	Non-Governmental Organization
NTFP	Non-Timber Forest Product
PRA	Participatory Rural Appraisal
WWF	World Wildlife Fund

Section 1. Introduction

Aims and structure of the essay

This essay reviews the results of research carried out over a period of 20 years in the Mesoamerican Tropical Dry Forest (MTDF), which are reported in the nine attached publications (listed in Annex 1 and referred to in square brackets throughout the essay).

The main aim of the essay is to review the contribution of these publications to the overall field of knowledge regarding the interactions between small farmers and trees in the MTDF, and how these relate to narratives that are dominant worldwide regarding farmer/tree relations. In order to provide a framework for the discussion, Section 2 introduces and discusses these narratives. Section 3, which is the core of the essay, then reviews the research results and discusses how they relate to these narratives.

The essay then takes a more critical approach, discussing, on the basis of this comparison between dominant narratives and the findings of the publications, how the processes whereby narratives arise and have influence might be improved, in order better to serve the diverse stakeholders that have interest in the MTDF and its inhabitants. This is the focus of Section 4. Finally, Section 5 highlights some issues that are likely to continue to pose challenges for researchers and practitioners working in conservation and development issues in the MTDF in the future.

Background to the research

The publications that support this essay are based on two projects funded by the Department for International Development[1] (DFID) of the UK Government: 'Forest Conservation and Tree Improvement' (CONSEFORH) and 'Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS).

[1] Formerly the Overseas Development Administration or ODA

These projects formed part of a series of investments by DFID in the MTDF, over a period of around two decades. The original interest of DFID in the MTDF stems from the potential that many of the tree species that occur there (e.g. *Bombacopsis quinata*, *Calliandra calothyrsus*, *Cordia alliodora, Gliricidia sepium* and *Leucaena* spp.) have to be used in commercial plantations or smallholder agroforestry systems throughout the tropics and subtropics. Earlier work focused on provenance exploration, seed collection and population studies of these species (e.g. Chamberlain 2001, Cordero and Boshier 2003, Greaves and McCarter 1990, Hughes 1998, Stewart et al 1996), with the aim of making their seed available for testing worldwide, and providing information on their reproductive biology and population diversity, that would guide the design of tree breeding and tree improvement programmes.

CONSEFORH and CUBOS followed on logically from those initiatives. Firstly, building on the knowledge of population biology of key native tree species generated by the species-specific research referred to above, CONSEFORH established plantations in southern and central Honduras that aimed to fulfil the dual functions of in-country sources of seed for forestry development, and *ex situ* genetic conservation facilities [1]. Subsequently, CUBOS examined how to design effective strategies for the conservation of tree species diversity in the MTDF that would respect local development needs and tenure conditions (NRI 1997); it shifted the focus from the research station onto the farm, and introduced a stronger emphasis on social issues – specifically, the need to integrate conservation strategies with smallholders' livelihood needs – that had been mentioned in the studies carried out until then, but not directly addressed.

Motivations of the research

The research reported in all of these publications was motivated by one concern: how to reduce the perceived loss of tree species diversity as a result of deforestation in the dry tropical forest zone of Mesoamerica, in a manner consistent with the livelihood needs of local people (NRI 1997, [1]). In fact, this overall concern can be broken down into a number of separate issues:

1) The existence in the MTDF of large numbers of native tree species, many of which are considered to have great potential to contribute to smallholders' livelihood support systems and forestry plantation programmes throughout the tropics;

2) The perception that deforestation, unsustainable harvesting of trees and agricultural practices are leading to the degradation of this resource;

3) The fact that the MTDF is home to a sizeable population of (largely poor) people, whose livelihoods are perceived to be directly threatened by the loss of forest cover and biodiversity.

4) The perception that the conservation strategies applied to date have been largely ineffective in addressing the perceived threats to the resource, and at the same time have not adequately taken into account the needs and conditions of the area's smallholder population.

The research complemented a considerable amount of activity by other actors in relation to biological research, forest conservation and the promotion of forestry and agroforestry in Mesoamerica. CUBOS, in particular, aimed to build upon these initiatives, complementing them by filling in key thematic gaps which they had failed adequately to cover. Specific problems that CUBOS sought to fill, in relation to the issues listed above, were as follows (NRI 1997):

- The limited amount of data available on the effectiveness of *in situ* and *ex situ* measures for the conservation of either inter- or intra-specific diversity in areas of forest fragmentation;

- The dominant focus to date of discussions related to conservation through use in managed agricultural and agroforestry systems or forest fragments, on agricultural crop varieties;

- The apparent negation of any potential role of farmer- and community-based protection, cultivation, management and use of trees in the agricultural landscape;

- The absence of studies which quantify the relative actual or potential contributions of *in*, *ex* or *circa situm* conservation in areas of high species diversity, or that investigate the socioeconomic factors likely to influence the relative success of different conservation strategies under different levels of forest cover and fragmentation;

- The focus of most studies regarding indigenous knowledge and use of plant species on relatively undisturbed environments.

The scope of the research

The two main objects of the research, and of this essay, are MTDF trees[2] and those members of the rural population who interact directly with them. For convenience, these actors (who in practice are highly diverse) are described variously and interchangeably as 'small farmers', 'farmers' and 'smallholders'. In fact, their characteristics coincide closely with the definition by Shanin (1973:63-64) of 'peasants', namely: "*a social entity with four essential and inter-linked facets; the family farm as the basic multi-functional unit of social organisation, land husbandry and usually animal rearing as the main means of livelihood, a specific traditional culture closely linked with the way of life of small rural communities and multidirectional subjection to powerful outsiders*". Given the baggage commonly associated with the term 'peasant', however – it is often taken to imply characteristics of backwardness, ignorance (Bryceson 2000) or semi-feudal labour relationships – that term is avoided here, except when referring to organizations of beneficiaries of agrarian reform processes, where it is used synonymously with the Spanish term *campesino*.

The focus of the essay on trees, meanwhile, as one element of the environment with which small farmers interact, is particularly instructive for a number of reasons. Firstly, farmers typically depend heavily on them for a range of products and services and, consequently, the nature of their relations with them is frequently a crucial determinant of the sustainability of their livelihoods. Secondly, any given

[2] Defined as 'woody individuals with a diameter at ground level of at least 0.5cm… Woody climbers [are] not included except those… that can have a climbing or scandent shrub habitat' [3].

tree population is typically the object of interest for a wide range of stakeholders, beyond the farmers who are in most direct contact with it, providing the opportunity to explore and compare relations of dependence and power between different stakeholder groups. Thirdly, trees offer the opportunity to explore tradeoffs, compatibility and complementary relations between local and global issues, which are of particular importance given the growing globalization of environmental concerns and decision-making structures. The essay also focuses specifically on trees, rather than forests, given that many interactions between rural people and trees take place outside of forests [2].

Conceptual framework

The conceptual framework used in the essay, regarding the relations between research, narratives and action, is summarized in Figure 1.

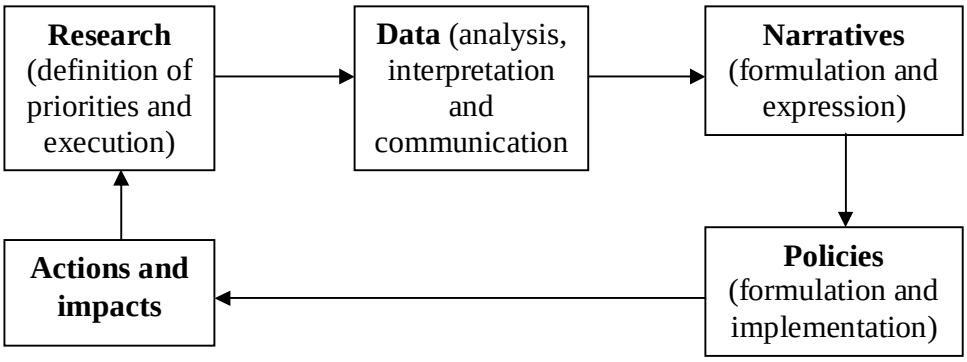

Figure 1: Summary of the route connecting research to action and impacts

According to this framework, which corresponds closely with that implicit in the work of Roe (1991), research (such as that reported in the supporting publications) generates data or evidence, which results in the formulation of environmental narratives (such as those reviewed in Section 2), which in turn provide the basis for the formulation of policies and of the plans and projects that are required to implement these and thereby generate impacts. The term 'narratives', which is referred to on repeated occasions throughout the essay, is defined by Forsyth (2003:97) as "*commonly heard environmental concepts and explanations*".

The reference to ‘realities’ in the title of the essay may at first appear more problematic. As Forsyth (2003) summarizes, views differ as to whether it is actually possible to define individual realities, with constructivists arguing that any postulated reality would in fact be an artificial construct determined by preconceptions and political standpoints. Forsyth goes on, however (ibid: 226-7), to argue for a rejection of “current definitions of environmental reality, *rather than the existence of reality itself*” (emphasis added). In fact, the title refers to a less abstract meaning of the term ‘realities’: the contrast between the sometimes facile process of formulating narratives, undertaken by powerful actors on whose livelihoods they have little impact, and the undeniable day to day realities of peasant families whose interactions with trees, as discussed in the sections that follow, have direct impacts on their livelihoods and are heavily dependent on the decisions taken by external actors.

As shown in Figure 1, this pathway from research to action is not (or should not be) linear: as pointed out by Roe (1991), learning should be inherent in planning processes, resulting in iterative modifications of narratives and policies on the basis of emerging evidence. Research itself also evolves as a result, leading to the development of new paradigms (defined by Kuhn (1962) as generalized trends of research that follow the investigation of particular themes or theories).

Section 2. Dominant Narratives of Smallholder/Tree Relations

In this section, I present a review of the some of the academic literature relating to the ways in which small farmers relate to trees. The principal aim of this exercise is to set the scene for an examination, in the next section, of what the attached publications reveal about such interactions in the specific case of the MTDF. It will become evident from this review that the research reported in the literature, much of which is based on case studies, has led to the formulation of a number of widely contrasting (and in some cases mutually contradictory) narratives regarding how small farmers interact with trees, which in many cases have had major implications for how small farmers have been treated by other actors.

In this review, I focus on those narratives with the greatest potential to influence, negatively or positively, the wellbeing of small farmers or the conservation status of tree species: for example, the types and magnitude of support which they have received from national Governments or international funding agencies, and the levels of restrictions that have been imposed upon their actions throughout the enactment and enforcement of legislation, or the establishment of restrictive protected areas.

The farmer as culprit

The narrative of the farmer as the cause of deforestation and other forms of environmental degradation is highly prevalent and influential in Mesoamerica, and is not limited to the dry forest zone: in the case of Honduras, "…*the image of severe and dramatic land clearance and degradation in smallholder fields has enabled politicians, readers of newspapers and journalists to draw the conclusion that bad land management is the central cause of environmental deterioration. Proposals to prevent such malpractice focus on the education of the land manager in order to raise awareness of ecological responsibility, or they centre on restricting access of producers to forested land*" (Jansen 1998:3).

This is a more specific version of the narrative that humans are incompatible with natural resource conservation – the "wilderness myth" (Fisher et al. 2005). A logical extension of this argument is that, if farmers are the culprits of environmental degradation, the more farmers there are, the more degradation will result. This argument corresponds with the theories proposed most notably by Malthus (1798) regarding the limited capacity of natural resources to meet the food needs of a growing human population, and more recently by 'neo-Malthusians' (e.g. Meadows et al 1972), who hold that when the limits of natural resources to absorb demographic and economic growth are exceeded, resources will be degraded. Such degradation leads in turn to increased poverty among the very people who cause it and whose livelihoods depend upon the existence of the resource base.

A number of counter-arguments to this narrative have emerged over the last several decades. Among the most influential works has been the overview by Boserup (1965) of agrarian change under pressure. Stated simply, Boserupian logic states that the more people there are, and consequently the greater the number of people among whom limited resources have to be shared, the greater the motivation and human resources there are to manage the remaining resources well.

The results of numerous location-specific case studies worldwide, particularly in Africa, have contributed to this debate. The emphasis of Stonich (1989) and Faber (1992) on negative forms of adaptation (coping) by Central American farmers experiencing pressure, appears to favour the small farmer-culprit narrative: farmers degrade as "*the short term costs of conservation to them are prohibitive*" (Stonich 1989:289)[3]. By contrast, the work of Leach and Fairhead (2000:18) in forest landscapes in West Africa questions the validity of Malthusian assumptions: the authors argue that the associated farmer-culprit narratives "*obscure widespread processes by which people have enriched landscapes with trees, and in which the peopling of the landscape has sometimes meant an expansion of tree and forest*

[3] Limited labour availability may be a significant barrier to Boserupian adaptation, as suggested by Stonich (1989), in the case of the labour-intensive construction of stone walls for erosion control, and the planting of trees (practices that have been widely promoted by extension institutions in Central America). However, by contrast, the cost and labour requirements of the practice of simply nurturing naturally-regenerated trees that is described in Publication 5 are very low.

cover where the opposite was assumed". Earlier, Tiffen et al (1994) also found a Boserupian response in Machakos, Kenya, leading in that case to reduced erosion: they concluded that concerns in the literature about whether human adaptability is sufficiently great to cope with high population growth rates were, at least in their study area, not realized. Connelly (1994:145), meanwhile, showed on Rusinga Island in Kenya that the Boserupian effect can also apparently function in reverse: there, "*labour scarcity resulting from migrant wage employment and the growing importance of the fishing industry has been a major factor in the decline of agriculture on the island*."

Doubts regarding Malthusian models actually go back further than this: in Central America, Durham (1979) concluded that the exclusion of Salvadorian small farmers from fertile land by powerful actors, and their subsequent concentration onto limited steep lands, was a more significant determinant of land degradation on the hills than simple population growth by pre-existing population there. More recently, Hecht et al (2006) reported forest recovery in El Salvador, which coincided with high levels of emigration: this finding appears initially to coincide with the Malthusian model, however in that case the relation appeared to work in reverse – fewer people led to more trees. In fact, the authors point out that rural population levels there are actually still on the increase, despite changes in age and gender structures and labour availability resulting from emigration: echoing the conclusions of Durham (1979) regarding the significance of agrarian equity or inequity as a determinant of forest conditions, they attribute the vegetation recovery partly to the Land Assignation Programme that occurred following the end of the internal conflict in the 1990s, which favoured a stable and diverse landscape with a significant content of woody perennials.

Large-scale quantitative studies on the causes of environmental degradation are few, due largely to the scarcity of reliable and comparable data. The wide-ranging empirical study by Geist and Lambin (2002) of the proximate causes and underlying driving forces of tropical deforestation in Africa, Asia and Latin America, is one exception. These authors concluded that "*contrary to widely held views… shifting*

cultivation [by small farmers] is not the primary cause of deforestation" (ibid:146). Importantly, in relation to Malthusian arguments, they found that "*contrary to a common misconception, population increase due to high fertility rates is not a primary driver of deforestation at a local scale*" (ibid:147). Butler and Laurence (2008:469) also suggest that a focus on small farmers as the culprits of deforestation is misplaced, and requires a change of strategy by conservationists: "*Rather than being dominated by rural farmers, tropical deforestation now is substantially driven by major industries and economic globalization…*"

In another version of this narrative, Hardin (1968) depicts a situation in which resource users with access to common property resources act on a purely individual basis and consequently degrade them in their personal interests. Hardin's 'Tragedy of the Commons' narrative has since been widely questioned (for example Haller and Galvin 2008) as it fails to distinguish between 'open access' and 'common property' resources (CPR) in which individuals' actions are influenced by governance structures and associated rules.

Many of the studies discussed above appear to suggest that Malthusian and Boserupian models are mutually exclusive: that it is a question of whether increasing rural populations will lead, in any given situation, to increases in resource degradation or to intensification and improved protection. In a case study from Madagascar, however, Locatelli et al (2004) found that these apparently opposing scenarios can actually succeed each other, resulting in a U-shaped graph of forest cover over time: in three landscapes with progressively greater population pressure, that study found, respectively, primary forest, extensive agriculture with short vegetation and, in the area with highest population pressure, a wooded and intensively managed landscape. In other words, a Malthusian process of population growth and corresponding land degradation brought natural resources to a critical level that stimulated a Boserupian process of intensification and recovery.

The farmer as victim

Another commonly expressed narrative, which at first sight appears to be the flip side of that of the small farmer as culprit, introduced above, is that of the rural poor

as the victims of environmental processes and of the degradation of natural resources. This is implicit in the sustainable rural livelihoods framework (Chambers and Conway, 1991) which highlights natural capital as one of the pillars on which the livelihood sustainability of the rural poor depends, the degradation of which by extension leads to livelihood vulnerability (poverty). Bass et al (2005) similarly highlight inadequate access to reliable asset bases as one of the multiple aspects of poverty.

Specific, often quoted examples, where the rural poor are considered to be victims of environmental factors, include increased difficulties in obtaining firewood, reduced availability of water, erosion and landslides (see e.g. World Bank 2005). While there is obviously a 'background' level of vulnerability to natural such phenomena, attention is increasingly paid to what is perceived as the anthropogenic nature of many of their underlying causes. This narrative came strongly to the fore in Honduras following the disastrous landslides and flash floods that accompanied Hurricane Mitch in Honduras in 1998: it was widely considered that deforestation had reduced the ability of watersheds to absorb extreme rainfall and the ability of trees to bind the soil against the risk of landslides. This narrative is gaining further force with the increasing levels of interest that are paid to the phenomenon of global climate change, which is widely expected to increase the vulnerability of large numbers of poor people worldwide to environmental hazards.

As well as being portrayed as victims of the irresponsible management and degradation of natural resources, the rural poor have also been depicted as victims of measures taken to conserve natural resources, such as restrictions on the forms of productive activity which they are allowed to carry out. Much of the discussion of the poverty impacts of conservation has taken place in relation to protected areas, particularly in Africa: specific examples of such negative impacts include the removal of the Phoka people in Malawi from their ancestral apiary grounds to make way for the Nyika National Park (Davey, 1993); the interruption of the nomadic hunting and gathering cycles of the Ik people in northern Uganda by the establishment of the Kidepo National Park (Turnbull, 1972); and the criminalization

of hunters in and around the Kasungu National Park in Malawi (Bell 1984). The accumulation of such evidence led to the formulation of a strong reaction against the protected areas approach by authors such as Dasmann (1984).

In recent years, the narrative of the rural poor as victims of natural resource degradation has been subject to similar forms of interrogation to those that have been applied to the farmer-culprit narrative discussed above. The fact that rural people's livelihoods depend on the existence of a sound natural resource base has not been cast into doubt; rather, researchers have tended to question the existence, magnitude and implications of some of the processes that are supposedly affecting this resource base. Pioneering works in this respect include the studies by Foley (1987) and Dewees (1989) reconsidering the narrative of the fuelwood crisis, which earlier authors such as Agarwal (1986) had considered to be placing in grave danger the livelihoods of large numbers of people in sub-Saharan Africa, and which had led to large investments of agency funding in reforestation activities. In the Central American context, Kaimowitz (2004) puts into perspective several common narratives linking deforestation to the hydrological services on which the rural poor and others depend, which have similarly been used to justify the expenditure of large amounts of agency funding. He describes these as "useful myths and intractable truths".

Regarding the view of the rural poor as victims of conservation, Upton et al (2008), in a wide-ranging empirical analysis covering 136 countries, likewise found "*few significant relationships between indicators of poverty and the extent of protected areas at a national scale*", suggesting that protected areas tend not to exacerbate poverty. Spinage (1998:274) similarly casts doubt on the validity of many of the claims of social impacts arising from protected area establishment, but concedes that "*There is no doubt much truth in some of the arguments of social injustice, and many injustices may have been perpetrated wilfully or ignorantly*".

Poverty and environmental degradation

A more specific but still common variation on the small farmer-culprit narrative is that small farmers degrade natural resources because poverty leaves them with no

alternative (e.g. WCED, 1987; Durning, 1989; UNEP, 1995; World Bank, 1992, all quoted by Ravnborg 2003): one aspect of this is the land scarcity which obliges farmers in much of Central America to cultivate steep hillsides that are vulnerable to land degradation (Durham 1979). The debates concerning relationships between poverty and environment are closely related to those concerning demography and environment, given that demographic changes and corresponding responses can have strong implications for poverty, in terms of levels of competition for scarce resources and the status of natural capital on which livelihoods depend.

As with the other nexuses discussed so far, that related to poverty and environmental degradation has been the subject of much research and debate, the findings of which have been varied, context dependent and/or inconclusive. Duraiappah (1998) carried out an extensive literature review in an attempt to determine if there was enough evidence to refute the hypothesis that poverty is a major cause of environmental degradation. She identified contrasting narratives, ranging from those which suggested a positive linkage, such as the Bruntland Commission Report and publications by the Asian Development Bank and World Bank (Jalal 1993, World Bank 1992), to others (typically later, indicating a change in the nature of the dominant narrative over time) that considered suggestions of such linkages as excessively simplistic (e.g. Leach and Mearns 1995), without however suggesting a negative relation. She concluded (ibid:2177) that "[the literature analysis] *demonstrates without a doubt that the poor do not initially or indirectly degrade the environment*".

There are a small number of studies on the poverty-environment nexus that are specific to Central America. Stonich (1989), whose research focused on the MTDF landscape of southern Honduras, highlighted the negative environmental effects of the extensive grazing practices carried out principally by medium to large farmers rather than the poorer sectors of society. Otherwise, she concluded that the very poorest were more likely to undertake practices causing environmental degradation, and less likely to undertake practices such as soil conservation, than the less poor, thereby apparently validating the suggested poverty/degradation linkage, referred to

above. The very poorest, defined as those who do not own land and who therefore have to cultivate on land rented from others, were described by Stonich as most likely to carry out burning and least likely to invest in soil conservation or tree protection.

By contrast, on the nearby hillsides of Nicaragua, Ravnborg (2003:1944) observed that: "*Due to the limited access of poor farmers to productive resources such as land, forest and forest resources, agro-chemicals and irrigation, the environmental impact of their resource management is limited in comparison with that of the nonpoor*", while, further afield in the Peruvian altiplano, Swinton and Quiroz (2003:1903) found that: "*natural resource sustainability is not correlated with poverty; rather it varies by management activity…soil erosion and fertility loss are reduced by fallowing, a practice of poorer farmers…overgrazing and range species loss are increased by herd size (a measure of wealth)*". Although these authors show that poverty/environmental degradation linkages do not necessarily hold water, neither is it safe to assume that the opposite (a wealth/environmental degradation link) does so consistently. Swinton and Quiroz (2003), for example, found that the beneficial practice of rotational grazing was [wealth] neutral, while deforestation due to fuelwood harvesting was largely carried out by poorer households.

The observations of Ravnborg (2003) from Nicaragua are interesting as they raise the issue of capacity to degrade – an issue which, as we will see in the next section, is important in the MTDF agroecosystem of southern Honduras – rather than simply motivation. The shortage of 'investment capital' of the kind required to carry out the forms of environmental degradation described by Ravnborg is one of the multiple aspects of poverty listed by Swinton et al (2003).

Despite these differing opinions regarding its validity, the perceived poverty/environment nexus is significant and influential as it is widely used to link the two preceding narratives: small farmers are portrayed as locked into a vicious circle in which they are the victims of the resource degradation of which they themselves are the culprits, and the resulting accentuation of their poverty leads

them to carry out ever more damaging forms of resource management and prevents them from investing in resource protection.

The farmer conservationist

An alternative narrative, that contrasts with the negative tone of those set out above, portrays farmers and other members of the rural population – and especially indigenous people – as active agents of conservation. This was the central hypothesis of CUBOS and will receive particular attention in the next section. This 'farmer conservationist' narrative has gained force over recent years, partly as a reaction to earlier portrayals of small farmers as helpless, ignorant or irresponsible degraders of natural resources: Kempf (1993:11), for example, describes how *"conservationists, including some park rangers, are finally learning what indigenous and ethnic people… have known for a long time: categories, electric fences, fire trucks and armed guards do not protect parks and the diversity of nature; people do."*

The narrative of the farmer conservationist covers a range of models that have been the subject of much experimentation and debate over recent years, and has gone far beyond the boundaries of formal protected areas: a satisfactory overarching term for this concept is Community-Based Natural Resource Management (CBNRM)[4]. Examples that are used to support this narrative range from the conservation of sacred groves in Africa in order to protect spiritual and cultural values (Sheridan and Nyamweru, 1996) to the conservation and sustainable extractive management of forests in Mexico (Bray 2005). Two separate arguments can be detected in the literature in support of involving rural people more in conservation: one based on their rights to continue to inhabit and use the lands to which they have traditionally had access, and for their livelihoods not to be impacted by conservation measures, and another more practical one based on their potential to complement the activities of outside conservationists. This latter view is based on the assumption that the fact that people use, or otherwise obtain benefits from resources, motivates them to

[4] Here CBNRM is taken to include initiatives taken within rural communities, rather than by external actors: it covers individual as well as collective initiatives, and those carried out in common property resources (CPR) as well as individually owned land and resources.

conserve them (McNeely 1988, Benson 1992 and WWF 1993, quoted in Freese 1997) – also known as 'conservation through use' (CTU).

There has been much idealism and over-generalization associated with the CBNRM narrative, whether rights-based or utility-based: this is typified by the privileging of local over scientific knowledge (Grillo and Stirrat 1997) and consideration of the rural poor as egalitarian altruists. Indigenous people, in particular, have been credited with acting as conservationists: for example Martin (1993:xvi) considers that "*Indigenous people… are the traditional guardians of the Law of Mother Earth, a code of conservation inspired by a universally held belief that the source of all life is the earth, the mother of all creation*" – a statement that fails to acknowledge the huge diversity that exists within and between indigenous groups and the evidence that some have been responsible for major environmental degradation even before contact with Europeans (see e.g. Glone and Wilmshurst 1999 in relation to the Maori of New Zealand).

This idealism has given critics of CBNRM a justification for cynicism and a rod to beat these concepts with, thereby perpetuating the successive shifts of opinion on the issue. Spinage (1998) goes as far as associating arguments that favour CBNRM-based approaches over traditional approaches to conservation with neo-populism and left-wing radicalism, while Robinson (1993), for example, considers that there should be a "limit to caring": in other words, a limit to the degree to which conservationists should try to meet social goals and a recognition that CBNRM cannot completely substitute stricter, more conventional approaches to conservation without losing significant levels of biodiversity and ecosystem function. Reporting the results of case studies in Nepal and Kenya, meanwhile, Kellert et al (2000:705) found that: "[CBNRM] *rarely resulted in more equitable distribution of power and economic benefits, reduced conflict, increased consideration of traditional or modern environmental knowledge, protection of biological diversity, or sustainable resource use*". These authors consider that CBNRM has had its day (ibid:706): "*CBNRM can be viewed as a modern attempt to revive often quite established and traditional local and indigenous cultural and institutional mechanisms for managing*

and conserving the natural environment", however *"the reality for much of the world… is that many traditional practices for regulating nature have eroded as a consequence of expanding markets, industrialization, urbanization, state power, economic globalization, and profound alterations in property rights, life-styles, and consumption patterns*". Freese (1997:23), meanwhile, warns against relying on the conservation activities of rural people, which are aimed at meeting their own needs, to conserve biodiversity in general: "*within any given biodiverse landscape, some components (genes, species, functional services) of that diversity will have greater economic value than others, leading humans to 'simplify and homogenize' to increase production of those more highly valued resources…specialized uses are grease for the slippery slope between biodiverse wildlands and the nondiverse agroscape*" (ibid:23). Belcher and Schreckenberg (2007), similarly warn that the economic use of forests, promoted with the intention of motivating conservation, can generate unintended negative impacts on biodiversity.

CBNRM, in all its guises, has also been the subject of research that has sought to determine the conditions under which it is able to function and meet expectations in terms of livelihood support and environmental sustainability. There is insufficient space in this essay to provide a complete review of the discussions on this topic: I therefore mention here two of the most important such publications on this issue. Based on a review of 14 case studies from Europe, Asia and North America, Ostrom (1990), for example, identifies eight factors that determine the robustness of the institutions on which the successful management of common-property resources depends: clear boundaries and memberships, congruent rules, collective-choice arenas, monitoring, graduated sanctions, conflict resolution mechanisms, recognised rights to organise and nested enterprises. Freese (1997) similarly presents a long list of conditions for commercial, consumptive use to be sustainable, which include the ability of markets to internalise costs and benefits, the valuation of future benefits, product demand and sustainability, the motivations of different stakeholders, the nature and location of resource rights, the existence of mechanisms for distributing benefits, and the inherent characteristics of the ecosystem in question.

Conclusions

One of the most obvious points emerging from the above review is the existence of multiple and at times conflicting narratives regarding how farmers interact with trees and forests worldwide. None of these narratives has managed to be accepted as an unquestionable, universal truth: one by one, following initial periods of enthusiasm and influence, each one has been queried by subsequent authors, typically on the basis of new evidence arising from case studies, resulting in what Kuhn (1962) described as "paradigm shifts". Conversely, some narratives have proven persistent and intransigent across time and space – what Latour 1987, quoted in Forsyth 2003, describes as "immutable mobiles" – "[policy narratives] *often resist change or modification even in the presence of contradicting empirical data, because they continue to underwrite and stabilize the assumptions for decision making in the face of high uncertainty, complexity, and polarization*" (Roe 1994:2).

These phenomena, of shifting paradigms and immutable mobiles, are of more than purely academic interest, in the MTDF as much as anywhere else. As summarized in Section 1, narratives guide policies, and policies – regarding, for example, commodity prices, trade liberalisation, tenure and the levels of state intervention in markets – in turn guide laws and investments that may absorb large quantities of scarce funds and have major positive or negative implications on the situation of peasants or of globally important natural resources. As discussed above, the narrative of farmers as culprits of environmental degradation has led in many cases to their exclusion from access to the natural resources on which their livelihoods depend: reaction against this situation has in turn been largely responsible for the emergence of the contrary narrative of the farmer as conservationist, which in turn has been accused of putting in jeopardy the conservation status of globally important biodiversity. Likewise, the questionings by authors such as Dewees (1989), Foley (1987) and Kaimowitz (2004) of the validity of prevailing narratives regarding the relations between environment and poverty could be interpreted as implying a reduced need for investment in support of natural resource-dependent peasants. This would imply ignoring the abundant evidence that exists regarding the persistence of

poverty among huge numbers of peasants worldwide, much of which is natural resource-related.

In addition, the pattern of successive paradigm shifts from one pole of the development/conservation or control/participation continua to another can result in the large scale waste of the funds that are available for conservation and development. Although these funds are large, they do not match the scale of the problems that face natural resources and peasants worldwide and any ineffective use therefore has a significant opportunity cost. Rejecting models wholesale on the basis of disappointing experiences, as is implied in some quarters with regard to farmer- and community-based conservation, also raises the risk of unjustifiably discarding solutions which, although imperfect, may still have significant elements of validity.

The main aim of the next section is not, therefore, to try and identify widely applicable new findings capable of overturning existing orthodoxies – resulting in new paradigm shifts – however attractive that prospect that may be as a means of gaining prestige in academia. Rather, the intention is to define what constructive contribution the research has made to the state of knowledge regarding the MTDF; contributions to the understanding of relations between farmers and trees worldwide will also be reviewed, but strict attention will be paid to delimiting the 'replication boundary' of any such findings, and on discussing how they may complement, rather than substitute, the findings of other studies to date.

Section 3. The Contribution of the Research

Having reviewed, albeit briefly, the types of narratives that are commonly applied regarding how rural people relate to trees, we now arrive at the core part of the essay, which examines what the attached publications have contributed to the state of knowledge regarding the validity of these narratives in the case of the MTDF. It will be seen that the reported research has shed important new light on how the MTDF functions in social and biological terms, and that some of these findings have potential implications beyond the MTDF. The section ends with a discussion of the degree to which it is safe or valid to attempt to generate more generalized lessons from the results of research of this kind.

The status of the MTDF

Fundamental to the views, discussed in the previous section, of rural people as either culprits or as victims of deforestation, is the assumption that deforestation is actually occurring. The MTDF in Central America is widely considered to be in an advanced stage of degradation: Janzen (1988), for example, describes tropical dry forest worldwide as "*the most endangered major tropical ecosystem*" and also (Janzen 1986a:308) presents a generalized portrayal of remnant trees and forest patches, such as those that constitute most of the remaining tree cover in the Central American dry forest, as "*living dead*" – referring to their low likelihood of reproductive success due to their increasing isolation from other individuals of the same species [1]. These views echo orthodoxies quoted by Forsyth (2003) in relation to tropical deforestation in general, referring, for example, to "*the fragility of tropical (often rain) forests* [and] *the role of forests in maintaining biodiversity*" (2003:39); these have been countered by new findings, which suggest that "'*deforestation' need not signify clearfelling, or complete loss of land cover… The role of disturbance… is acknowledged as a source of change and development of biodiversity within certain forest ecosystems. Biodiversity also need not be maintained only through preserving forest areas, as neighbouring grasslands or savanna systems may also have high biodiversity*" (ibid:39).

The supporting publications provide important insights into the validity of deforestation narratives concerning the MTDF. A key issue that is evident from the publications is that there are many ways of defining the status of the MTDF, and that the validity of deforestation narratives depends on the definition that is used.

1) Biological productivity

Janzen (1988) refers to the "*intensive clearing up of the Mesoamerican dry forest landscape*". The publications suggest that this description is indeed appropriate to the lowlands of the Pacific coast of Honduras and Oaxaca, which have been subjected to wholesale clearance, including the mechanical grubbing up of stumps [7]. The picture on the hills of southern Honduras is very different, however: here, although the original forest cover has been almost completely converted to an agroecosystem made up of a mosaic of fields, fallows, pastures and small remnants of secondary forest, large quantities of live tree material persist, even in the middle of fields under active cultivation; this material is able to develop rapidly into closed canopy fallows and secondary forest if allowed [2]. This regenerative capacity is by no means typical of tropical ecosystems: a particularly large number of MTDF trees have vigorous coppicing ability and aggressive seed dispersal strategies (including wind dispersal and explosively dehiscent pods).

2) Biodiversity:

I refer to biodiversity in this essay as the total number of different species present in a given location or ecosystem. The total number of tree species (194) reported in the publications in the highly disturbed conditions of southern Honduras was of the same order or magnitude as that (252) found in the much less disturbed conditions of coastal Oaxaca, where extensive areas of apparently intact forest exist [5]. Although, as discussed below, anthropogenic disturbance may modify species composition, it therefore appears that it does not necessarily lead to massive reductions in levels of biodiversity.

3) Bioquality

Hawthorn and Abu-Juam (1995) use the term bioquality to refer to the numbers of species of high conservation priority in any given site: this concept is more useful

for defining conservation priorities than biodiversity, which might lead to sites with large numbers of common and non-threatened species being prioritised over others that contain species under imminent threat of extinction. Using this measure, the picture in the MTDF agroecosystem is less positive. The results of the botanical surveys reported in the publications showed that the abundant tree material found in the southern Honduran agroecosystem contains very few species of global conservation concern, compared with the large expanses of apparently intact forest and long term fallows in the Oaxaca study area [3 and 5]. The degree to which this is due to natural latitudinal variations in species diversity or to anthropic influence is discussed below, in relation to small farmers' tree husbandry practices.

4) Biological function:

Even in the highly fragmented agroecosystem of southern Honduras, there are high levels of gene exchange between apparently isolated individuals of species such as *B. quinata*, which suggests that "descriptions of remnant trees and forest patches as 'isolated' or 'living dead' (Janzen 1986a), with little or no conservation value, may be misleading and more human perception than a true reflection of actual gene flow or any biological reality" [6]. A specific focus on individual tree species says little about the biological functioning of other biota or of the ecosystem as whole, including predator/prey relations, or interspecific dependencies for functions such as pollination. This evidence of continued reproductive potential, coupled with the robustness and regenerative vigour of many dry zone species, does however raise the possibility that much of the "intensive clearing up of the… landscape" of which Janzen (1988) may not be irreversible, as Janzen (1986b) himself has demonstrated through the ecological restoration initiatives which he reports in abandoned cattle ranches in the MTDF zone of Costa Rica.

5) Intactness

Janzen (1988) backs up his concerns about the conservation status of the dry forest by the statement that only 2% of its original extent across Mesoamerica is in a state "*sufficiently intact to attract the attention of the traditional conservationist*" – which is assumed to mean similar in structural and compositional terms to the original

vegetation, and therefore able to support similar levels and types of species diversity and ecological processes (such as gene flow and predator/prey relationships). According to this criterion, Janzen's degradation narrative appears to be largely accurate in relation to the Central American MTDF landscape, the vast majority of which has unquestionably already been converted to something structurally and compositionally very different to what was originally there [7]. Intactness has different implications for different components of the biota, however: groups such as birds (Barrantes and Sánchez 2004) and herpetofauna (Sasa and Bolaños 2004) appear much more vulnerable to modifications of forest structure than do trees; however it is also evident that some MTDF tree species, such as *B. quinata*, do not regenerate well in disturbed environments [6].

6) Social productivity

Deforestation narratives also commonly refer to reductions in access to forest goods and services by local people, as a result of the loss of forest cover (e.g. Agarwal 1986) – one of the variants of the 'farmer as victim' narrative introduced in the previous section. However, at least in the southern Honduran study communities, the structural and compositional changes that have affected the original forest cover appear not to have significantly increased levels of scarcity of tree and forest products among farm families [8]: their needs for fuelwood are largely satisfied by casual collection of dead branches found in the vicinity of the house, and by trees felled during the cyclical process of clearing fallows for cultivation, while needs for timber and posts are largely met by naturally regenerated trees that are actively protected by farmers in the middle of their fields. However, although informants reported generally good availability of these products, the results of one focus group in southern Honduras [6] did indicate that local inhabitants had been obliged to turn to species that yielded lower quality products than before, as a result of the elimination of preferred species.

Whichever measure is used, it is clear that the changes that have occurred in the MTDF since pre-Colombian times have been non-linear [7], and also have also shown much spatial variation, both within and between different landscapes in the

MTDF zone: in some parts of southern Honduras the landscape appears to have remained stable in overall terms (with only changes of a cyclical nature) while in others there has been an obvious reduction in the proportion of fallow and woodland in the landscape, and a progressive subdivision of land holdings.

The role of small farmers in deforestation

The supporting publications suggest that narratives of small farmers as agents of deforestation contain elements of truth, but also inaccuracies and gross simplifications. As discussed above, it is undeniable that almost all of today's MTDF agroecosystem in southern Honduras, and a significant part of that in coastal Oaxaca, is very different to what may be assumed to its original, natural condition [3, 5 and 6], and that, at least on the hills, those who have been at the forefront of this conversion process, actually cutting the trees down, have mostly been small farmers (with some exceptions, such as the study community of El Sanjón in Oaxaca, where interviewees reported that Government agencies had been directly involved in clearing forests [7]). Despite this evidence, the publications suggest that it is not necessarily safe to conclude that small farmers in the MTDF continue to be active agents of deforestation, or appropriate to assign blame to them for their role in deforestation, for a number of reasons.

Firstly, there is the question of how one defines deforestation. As discussed above, reductions in tree species biodiversity in the Central American MTDF, or in its ability to yield products for the rural population, have not occurred in direct proportion to changes in the physical structure of the ecosystem (by which deforestation is typically understood).

Secondly, although small farmers may be, or may have been, the immediate agents of impacts on the MTDF, the underlying causes of these impacts are largely beyond their control. Durham (1979) concluded that the main underlying cause of land degradation on the hills of El Salvador (adjoining the southern Honduran study area) was the exclusion of small farmers from the fertile lowlands by powerful landowners and commercial interests, leaving them with no option but to farm steep hillsides: their concentration onto this reduced area accelerated the impacts of their

farming practices on the condition of natural resources on the hillsides. Similar processes of exclusion have affected small farmers in much of southern Honduras [7], a situation which commenced after the Spanish conquest (Newson 1986), was perpetuated by deeply entrenched power imbalances in post-independence society and was further exacerbated by initiatives aimed at promoting economic development such as the US-sponsored Alliance for Progress (Jansen 2000, Stonich 1989).

The apparently obvious solution to this situation would be to reduce farmers' marginalization onto the hillsides, through processes of agrarian reform. In southern Honduras, however, examination of historical aerial photographs and interviews with farmers suggest that this appears in fact to have exacerbated deforestation [7]. Again, though, this is largely due to factors outside of the farmers' direct control. Farmers in one of the study communities, which was established through the agrarian reform programmes of the 1960s and 1970s, explained that the way that agrarian legislation was interpreted obliged them to clear forest from their land in order to demonstrate that it was fulfilling its 'social function', or they would risk the land being taken away from them again – in practice, they did retain some areas of woodland as sources of tree products, but only in areas that could not be seen by outsiders [7]. The inability and limited motivation of some *campesino*[5] groups to invest in sustainable management of the natural resources on the land they received was also partly to their limited confidence in their long term rights over the land[6] and the limited levels of financial and technical support provided by the Government, which in turn was largely due to limited genuine commitment to the agrarian reform process by the landowning elites that dominated the Government. This situation contrasts sharply with that in neighbouring El Salvador, where Hecht at al (2006) suggest that the Land Assignation Programme that occurred following the end of the internal conflict in the 1990s has had a positive impact on forest

[5] Organized farmers entitled to benefit from the agrarian reform
[6] Many handovers of land to *campesino* groups were successfully challenged later by the original landowners, leading to forced evictions

cover, by favouring a stable and diverse landscape made up of small farms containing large numbers of trees.

Such findings, which call into question the validity of the common narrative of small farmers as culprits of deforestation, correspond with those of Geist and Lambin (2002) and Butler and Laurence (2008), referred to in the previous section, regarding the proximate causes and underlying driving forces of tropical deforestation. The evidence does not, however, permit a simple rebuttal of the 'farmer – culprit' narrative on the southern Honduran hills: the concentration of population onto the hills is due not only to 'push' factors (exclusion from the lowlands) but also to 'pull' factors, such as the gold mining development in the village of El Corpus in the 19th century, to which small farmers responded by increasing agricultural production to meet the food needs of the miners and their dependents [7]. It is also indisputable that reproductive growth of the rural population following marginalization onto the hillsides has been a major factor leading to farm subdivision and the reduction in the area of fallow in the landscape [8].

Thirdly, there is clear evidence in the MTDF of small farmers taking action to conserve their remaining tree and forest resources, rather than degrading them [2, 7 and 8]. On the hills of southern Honduras, these actions take the form of the active husbandry, by individual farmers, of trees that they find regenerating naturally in their fields; in coastal Oaxaca, meanwhile, communal authorities have introduced regulations to conserve remaining forest areas in order to ensure community members' continued access to forest products. The insights provided by the supporting publications into the validity of this view of the 'small farmer as conservationist' are discussed below.

Tree husbandry by small farmers

CUBOS aimed specifically to examine the validity of the concept of the 'farmer as conservationist': it constituted perhaps the most detailed study that has been carried out to date of the tree management practices applied by small farmers in the Central American MTDF agroecosystem, and complements studies in other ecosystems and farming systems in the region, such as those of Harvey et al (2004 and 2005). On a

technical level, the results are important as they highlight endogenous alternatives to the typically exogenous practices promoted by many institutions working with smallholders in the area. These endogenous practices require minimal investment of time or money and no community organization, and are pre-adapted to the constraints of existing farming systems. Conversely, they depend on there being adequate resources of live stumps or seedlings, of the species preferred by farmers, to be subjected to husbandry. It was observed during the CUBOS fieldwork that the quantities of natural regeneration and the predominant species mixes varied greatly across the study area (due apparently to a combination of natural patterns of species distribution and variations in previous land uses), meaning that there was no guarantee that preferred species would be available for husbandry at any given site.

The findings are also important as they go beyond technical descriptions of tree husbandry practices, and identify the factors that motivate and constrain their application, and how they relate to the dynamics of the MTDF landscape as a whole [2 and 7]. These factors include:

i) *The livelihood importance of the goods and services provided by trees:* southern Honduran smallholders have limited access to alternative building materials or energy sources, therefore protect trees that can provide them, unlike those in the study community of El Sanjón, Oaxaca, who did not need to manage their own trees, **and/or**

ii) *Demand for tree products as a cash crop:* the evidence from Los Coyotes study community in Honduras was that tree husbandry was significantly more profitable when good commercial markets existed for timber – elsewhere, opportunities to sell posts and timber to other community members also provided an important motivation for tree husbandry; **and**

iii) *An increasingly scarce tree resource:* southern Honduran farmers have little access to off-farm trees, so have little alternative but to protect them on farm (in their fields); in contrast, the inhabitants of most of the Oaxaca

study communities have access to abundant common pool forest resources; **and**

iv) *Limited land opportunity cost:* topographical and climatic conditions on the southern Honduran hills mean that farmers can only grow low value crops such as maize and beans, so the loss of agricultural income is not a major disincentive to maintaining trees in the midst of crops; this contrasts again with El Sanjón, where the opportunity to grow lemons on the irrigable flat land means that husbandry of relatively low value trees would incur a significant opportunity cost; **and**

v) *A favourable legal environment:* many farmers in southern Honduras reported legal obstacles to selling and transporting timber as a major disincentive to tree husbandry, compared to alternative vehicles for income generation and savings such as cattle.

The findings in southern Honduras contribute to the growing body of evidence supporting the observations of Boserup (1965) regarding the ways in which agrarian change occurs in response to pressure, such as the studies in Africa (e.g. Connelly 1994, Locatelli et al 2004, Tiffen et al 1994) quoted in the previous section. Stated simply, this logic is that the more people there are, and consequently the greater the number of people among whom limited resources have to be shared, the greater the motivation and human resources there are to manage the remaining resources well. On the southern Honduran hills, this apparent Boserupian improvement in resource management, in response to scarcity, seems to play an important role as a 'social safety net', given the generally low and largely stable levels of difficulty reported by farmers there in obtaining adequate quantities of tree products [8]. This landscape transformation has probably not been cost-free in social terms, however: the inhabitants of the southern Honduran agroecosystem have less free or wide access to ecosystem goods and services (such as hunting and the potential to gain income from ecotourism or the sale of hydrological services) than their counterparts in more heavily forested landscapes, such as those in the Oaxaca study area.

The comparison between the study areas in Oaxaca and southern Honduras [8] is also important as it allows such apparent Boserupian processes to be judged simultaneously from both social and biological viewpoints. Their ability to act as 'safety nets' in biological terms, capable of stemming local species extinctions resulting from the loss and degradation of forest cover in once densely wooded landscapes, is called into question by the fact that the southern Honduran agroecosystem has much lower bioquality than the forests and mature fallows of Oaxaca [4 and 5]. It is not in fact clear to what extent this difference in bioquality can be attributed to disturbance or to latitude (Gentry 1988 and 1992); however the comparison between *B. quinata* and *S. humilis* [6] supports the suggestion that less robust species may indeed be at risk of local extinction during the process of transformation from wooded landscape to agroecosystems.

Community-level natural resource management[7]

The research in coastal Oaxaca [7 and 8] contributes to the growing volume of literature on community-level initiatives and mechanisms for natural resource management in Mexico (e.g. Bray 2005), and allows the positive accounts of such authors, together with the more pessimistic conclusions of authors such as Kellert et al (2000), quoted in the previous section, to be tested within the context of the MTDF. It offers the opportunity, moreover, to test the broader replication potential of those earlier findings in Mexico, which had largely focused on lowland humid and upland pine forests with generally larger standing volumes of marketable timber than the MTDF.

The research in Oaxaca provided evidence that community organizations, acting according to the provisions of agrarian law, may take decisions to ensure the protection and sustainable management of forests even when the potential to generate immediate financial benefits, for example through timber sales (the main motivation in the cases reported by Bray 2005), is limited. The findings did not

[7] In contrast with the tree husbandry by individual farmers, discussed above, this term refers to collective actions within local communities, related either to common property resources or to individually-owned resources over which the community as a whole has some influence. It is therefore more specific than the term 'CBRNM' used in the previous section.

completely discount financial interest as a motivation: in the case of Santa María Huatulco, Oaxaca, the continuing conservation of communal forests was "partly motivated by perceptions of a demand for ecotourism and ecological services" with perceived potential to generate financial income for the communities, and non-timber forest products with potential to generate income for individuals [8]. These marketable forest goods and services were however complemented by a number of non-marketed goods and services such as hunting, and timber and fuelwood for subsistence use; some communities had no access to external markets for goods and services, and in those cases the motivations for forest conservation were entirely non-financial in nature.

The research in the Oaxacan MTDF also showed that effective community-level mechanisms for natural resource management are not limited to indigenous communities, on which much of the other literature on this issue from Mexico and elsewhere in Latin America has focused. Rodríguez Canto (1996) suggests that, although the current system of *ejidos* and agrarian communities (which is central to the resource management and governance systems that were encountered) has its original roots in indigenous forms of social organization, its present form derives from its revival in the 17th century as a form of social survival strategy in the face of hardships during the colonial period, and its subsequent formalization following the Mexican revolution at the beginning of the 20th century. Furthermore, although the communities studied in Oaxaca had more recent indigenous connections than those in southern Honduras (some older members there still spoke indigenous languages), all of them had been established within living memory due to migration from elsewhere in the coastal region, or in some cases from indigenous communities in the interior of the State, and therefore lacked truly ancestral ties to the land and natural resources of their present locations.

The evidence, from most of the Mexican study communities, of effective community-level mechanisms for natural resource management and governance, lends more weight to the widespread questionings (e.g. Haller and Galvin 2008) that have been levelled at Hardin's (1968) suggested linkage between common property

resources ("commons") and resource degradation: the communally-owned forests found there were far from open access in nature – indeed, one of the main motivations for these systems was the collective assertion of territorial rights in order to prevent incursion by outsiders – and individual community members' interactions with them were subject to rules defined by community organizations.

The findings do, however, also show that such systems have their limitations, including the following:

- *They can be undermined by market forces*: this appeared to be the case in the community of El Limón, where community-based regulations were reported to be ineffective in the face of apparent over-exploitation of *Amphyteringium adstringens* bark, motivated by the existence of lucrative and accessible markets for this product; and also in El Sanjón, where the existence of lucrative markets for the products of alternative land uses (lemon plantations), rather than of the forest itself, motivated forest clearance and the individualization of *de facto* land tenure and resource management. These observations are a useful counterpoint to those of authors such as Bray et al (2002) regarding the positive aspects of market access, as a prerequisite for successful community-based forest management.

- *They have limited effectiveness outside of the common property resource areas themselves*: in El Limón, community members explained that in the areas that had been allocated to each for their individual use, their actions were largely unconstrained by the types of regulations applied to the common property areas with the aim of protecting the interests of the community as a whole.

- *They can represent a barrier to the realization of the productive potential of the resource:* in the Oaxacan study community of Petatengo, some interviewees expressed opposition to a proposal to carry out sustainable harvesting of wood from *Bursera* spp. to produce marketable sculptures (*alebrijes*), supported by a local NGO [8]; there was concern that this would

result in inequitable individual capture of benefits from the common property resource.

- *They do not necessarily guarantee equity:* opportunities for participation in decision making are highly biased towards men, and *avecindados* (inhabitants without formal status as members of the community) are likewise excluded; in Petatengo, meanwhile, community members considered that if a decision to prohibit the establishment of individually fenced enclosures, to prevent the marginalization of the poorer members of the community, were to be put to the vote again, it would be rescinded because the less poor (with the resources with which to fence) now outnumber the poorer.

Despite these deficiencies, the systems encountered have proven to be remarkably robust over time: in one form or another, they have survived the Spanish conquest, one process of Liberal reform at the end of the 19th century, a subsequent process of neo-Liberal reform at the end of the 20th century, and major processes of internal migration [7]; there was little evidence of community members wishing fully to privatise their communal holdings as provided for in the 1992 modification to the Mexican Constitution [8]. In other words, in contrast to the suggestions of Kellert et al (2000) in Kenya and Nepal, the community-level systems found in coastal Oaxaca, as in many other parts of Mexico, continue to have major potential for delivering both biodiversity and livelihood benefits. This does not permit complacency, however: to survive, these systems will have to continue to adapt to changing circumstances, such as creeping privatisation, rural depopulation, Government-backed incentive schemes based on neo-Liberal principles and changes in the relative viability of different agricultural production systems.

Although not perfect, these community-level systems set coastal Oaxaca strongly apart from the Central American MTDF agroecosystem, where land tenure and resource management decisions are on an almost exclusively individual basis. This contrast is discussed further below.

Conservation through use

Conservation through use (CTU) is defined in the attached publications as the "conservation of any resource, motivated by perceptions of its utility" [8]. The research results confirmed that CTU is very much in evidence in the MTDF, given that all of the cases reported of farmers there acting as conservationists were motivated by their perceptions of the potential to receive benefits from the conserved resource [2, 7, 8], rather then altruism. The research also shows, however, that CTU can take many shapes and forms, and that its boundaries are debatable. The key distinctions encountered in the MTDF are discussed below.

Active vs. passive CTU

The exploration by Freese (1997) of the 'use it or lose it debate', focuses on "the commercial, consumptive use of wild species". The 'utility' referred to in the definition of CTU posited above [8] may arise from the physical extraction of products and/or active management of the resource, resulting in possible modifications to its condition; or the passive ("hands-off") enjoyment of benefits such as existence value or environmental services. The inclusion of this second scenario as CTU is debatable, as it could also be termed 'conservation through non-use': the key issue here, however, is that the appreciation of benefits of any kind from a resource can motivate its conservation; this implies the need for careful tracking and, where possible, quantification of such benefit flows in order to promote their equitable internalization through conservation initiatives.

The key practical implication of the distinction between *active* and *passive* CTU is the risk that the former may lead to negative biological impacts on the resource in question, such as the specialization of which Freese (1997) warns (see Section 2). On the southern Honduran hills, the fact that farmers obtain use benefits principally from a few most-valued species, and that it is only these that they actively protect as standing trees in the agroecosystem [2], would seem to coincide with this concept of specialization: one would expect the landscape to be dominated by species such as *Cordia alliodora*, *Gliricidia sepium* and *Lysiloma* spp., at the expense of (less useful) others. In fact, such standing trees made up only 0.3% of the total number of

individuals present, which were of 89 different tree species, the vast majority of which were not specifically valued by the farmers at all [8]. The main pressure on the agroecosystem in this case was therefore disturbance (the species found were by definition the most robust, capable of surviving in highly disturbed environments), rather than favouritism towards valued species. Freese's dichotomy, with its implication that agroscapes have little or no biodiversity compared to wildlands, is a classic example of an environmental orthodoxy (sensu Forsyth 2003), and bears little relation to the case of the MTDF, as discussed at the beginning of this section.

Commercial vs. subsistence use

The main emphasis of Freese (1997) and of much of the literature on non-timber forest products (NTFPs) (e.g. Neumann and Hirsch 2000) and on community-based forest management (e.g. Bray 2005) is on commercial forms of CTU, whereby natural resources are conserved because of their ability to generate income. In the MTDF, by contrast, most of the CTU that was observed was centred on goods and services for subsistence use, for a number of reasons including difficult access to markets and the lower volumes and quality of products that the MTDF is able to produce compared with ecosystems such as pine and humid broadleaved forests [8]. This is significant, as it limits opportunities to use market-based instruments such as product certification to increase the benefits that farmers perceive from resources, and their corresponding motivations to conserve them; conversely, it buffers CTU against variations in market prices which, when low, may result in reduced commitment to conservation and, when high, may motivate overexploitation of the resource (as appears to be occurring with *A. adstringens*, as discussed above).

Direct or indirect CTU

In the case of tree husbandry on the southern Honduran hills, the beneficiaries of the goods and services provided by the resource were the same people that were consequently motivated to conserve it – what may be termed 'direct CTU' [8]. The community-based regulation reported in Oaxaca, however, involved not only self-regulation by community members in order to promote their collective interests, but also regulation of the actions of actors who had limited or no rights to enjoy benefits

from the resource (such as *avecindados* and outsiders). This may be termed 'indirect CTU', whereby resource beneficiaries act through others – either by regulation or incentives – to promote the conservation of the resource which provides them with benefits. In another case in Oaxaca, such an indirect CTU loop had been proposed but had not yet materialized, in the form of suggested schemes for payments by downstream water consumers, to motivate people upstream to conserve the forests on which the water supply was considered to depend. The indirect beneficiaries can therefore be either inside or outside the community where the resource managers live: the important point is that there must be a positive 'externality' which goes beyond the interests of the resource manager his or herself. Such an 'externality' was in fact at the heart of the reasoning behind CONSEFORH and CUBOS, in the form of the potential for the MTDF to provide genetic material of use to foresters and farmers worldwide. As will be seen below, these contrasting direct and indirect scenarios differ in terms of the conditions that must be met in order for the CTU to function, and also raise differing ethical and distributional issues.

Species or ecosystem level CTU

The tree husbandry encountered on the southern Honduran hills operated at the level of individual trees of individual species: farmers protected trees that were of potential use to them and did their utmost (albeit with limited levels of success) to eliminate others in order to minimize their negative impacts on agricultural crops [2]. By contrast, communities in Oaxaca took measures to protect whole blocks of forest ecosystem in order to ensure their continued access to the diverse goods and services that these delivered [7, 8].

The conditions for effective CTU

The findings in southern Honduras and coastal Oaxaca suggest that the effectiveness of CTU is dependent on a number of conditions being met. These conclusions complement those of Freese (1997), but add new dimensions, by distinguishing between the conditions required for species and ecosystem level CTU to work (see above), and for CTU to contribute, respectively, to biodiversity conservation and to local people's livelihoods. The findings are summarized in Table 1.

Objective	Level at which CTU operates	
	Species	**Ecosystem**
Conservation of rare tree species	- Secure individual long-term rights to tree use - Favourable regulatory context - Favourable biophysical environment for tree regeneration - High levels of demand or need for tree goods and services - Low levels of opportunity cost associated with tree management - Awareness of silvicultural potential and yield of the species	- Need or demand for ecosystem goods and services - Long-term capacity of ecosystem to produce goods and services - Compatibility between provision of goods and services and conservation of priority tree species - Effective governance structures based on awareness of ecosystem goods and services
Improvement of livelihoods	- Secure individual long-term rights to tree use - Favourable regulatory context - Favourable biophysical environment for tree regeneration - Large resource of useful and vigorous trees - Access to markets for tree products	- Appreciation of ecosystem's role by its managers - Ability of ecosystem to produce valued goods and services - Compatibility between enjoyment of goods and services, and resource conservation - Effective mechanisms for distribution of benefits or compensation of costs - Effective mechanisms for participation by resource beneficiaries in its management - Effective regulation of resource use and management

Table 1: Conditions for effectiveness of CTU in the MTDF [8]

The relevance of poverty

The results of the CUBOS research suggest that the validity of positive linkages between poverty and environmental degradation (e.g. WCED, 1987; Durning, 1989; UNEP, 1995; World Bank, 1992, Stonich, 1989), depends again on the definitions used, of poverty, degradation and conservation. On the hills of southern Honduras

there is in fact strong evidence that poverty (defined as scarcity of land and access to alternative sources of tree products) leads to conservation, rather than to degradation [2]: in the words of one Honduran farmer, "*con la escasez viene la inteligencia*" – "with scarcity comes intelligence" (shown by actions such as tree husbandry that serve to stave off increases in scarcity).

The presence of large amounts of inconspicuous live tree material in farmers' fields in southern Honduras [2 and 8] introduces another form of relationship between poverty and conservation: that of the 'conservationist by default', and the issue of farmers' capacity to degrade, as opposed to the capacity to conserve, that was emphasized by Stonich (1989). Much of this live tree material, which is of little use value to farmers and in fact competes with their crops, survives despite farmers' best efforts to eliminate it. They are unable to do so for a number of interrelated reasons, all of which are aspects of poverty: they lack the financial and technological resources with which to grub out tree stumps; and their marginalization onto the steep hillsides, and consequent poor access to irrigation and markets, limits their ability to produce higher value crops than maize and beans, that would warrant such investment. This coincides with the findings of Ravnborg (2003:1944), on the hillsides of Nicaragua, regarding the limited environmental impact of poor farmers compared to the non-poor, due to their limited access to productive resources.

It is important to recognize that different types of conservation actions vary in relation to their compatibility with the resource availability of the poor. Activities such as the construction of soil conservation barriers and the planting of trees, mentioned by Stonich (1989), are indeed highly demanding of labour and may therefore be beyond the reach of the poorest sectors of society, whose labour has a high opportunity cost in relation to their overall family budgets, and who have limited availability to pay for hired labour. By contrast, husbandry of naturally regenerated trees requires little or no investment of labour or money, apart from occasional pruning aimed at achieving the desired balance between tree and crop development [2].

Comparisons between communities in southern Honduras and coastal Oaxaca provide interesting further insights into these relationships between poverty and environmental degradation. The case of El Sanjón, in Oaxaca [7], lends further credence to the posited positive link between poverty/scarcity and tree husbandry: that was the only Mexican study community that had no significant areas of forest remaining within easy reach of most of its inhabitants, yet there was no evidence of the kinds of tree husbandry that southern Honduran farmers apply in response to scarcity: the apparent explanation was that community members in El Sanjón had sufficiently good access to income (from lemon production and off-farm employment) that they were able to use other means – purchase from outside of the community – to satisfy their needs for the kinds of products typically supplied by trees, and so had no need to carry out tree husbandry, which in any case would have had a significant opportunity cost in terms of lost lemon production. In this case, therefore, relatively low levels of poverty resulted in low levels of conservation activity.

Conversely, the results of economic studies carried out in two communities in southern Honduras (Richards et al, 2000 [8]) suggest that, despite the apparent overall validity of the finding that tree husbandry is motivated by scarcity, in some cases there may be positive relations between tree husbandry and income: when there is particularly good access to markets for tree products (as was the case in Los Coyotes, which is located near to cottage industries producing furniture of *Cordia alliodora*), farmers with more land (the most common criterion of wealth defined by community members) are better able than smaller farmers to respond to this demand by retaining higher densities of *C. alliodora* trees in their fields.

Conclusions

The findings reported in the publications have the potential significantly to modify perceptions of the MTDF and its inhabitants, and to shed further light on the replication potential of other researchers' findings regarding interactions between small farmers and natural resources in other ecosystems. The MTDF has largely been neglected by researchers and policy makers to date, compared with the more

economically productive pine forests of the mountainous interior of Mesoamerica and the humid forests of the Caribbean slopes and lowlands. The findings also confirm the importance of avoiding a similar bias towards natural forests at the expense of disturbed agroecosystems – of applying a "conservation biologist's lens" (Vandermeer and Perfecto 1997) to the agroecosystem, but also the lens of a sociologist (the findings in fact suggest that tree husbandry in the MTDF agroecosystem is more effective as a social than as a biological safety net).

The findings also lend further weight to calls for a questioning of generalized narratives that portray small farmers, variously, as self-interested culprits of environmental degradation, wise and effective conservationists, or victims of environmental degradation or conservation initiatives. The publications make it clear that, in the MTDF, none of these caps fits adequately: to deny, for example, that farmers are culprits of environmental degradation would place them on an artificial plane whose separateness from the rest of the world would be unrealistic; to deny that they are victims would understate the seriousness of their poverty and overstate their capacity to adapt, and thereby invite inaction; and to deny that they are conservationists would deny their rationality. As pointed out by Fisher et al (2005:27), there is "*…a serious problem with much of the discussion about people and conservation — the tendency for the sort of argument that says that people are essentially one thing or another and always behave in a certain way. The problem with such an argument is that it fails to account for context. Behaviour, whether conservationist or exploitative, always occurs in the context of complex social, economic and environmental circumstances*."

Despite these notes of caution, the research has permitted the tentative identification of a number of different forms of relation between small farmers and MTDF trees, and the recommendation of corresponding conservation and livelihood support strategies. As discussed above with narratives, these relations and solutions are not particularly tidy or uniform: what may be needed in the MTDF is a combination of such approaches, tailored to the diverse needs of its different stakeholders at local, national and global levels, and to the wide diversity of biophysical, cultural,

economic, demographic and tenure conditions that occur across its range. These are likely to include a combination of *in situ* and *circa situm* approaches; of strict 'hands off' conservation and conservation through use; and of self-regulation at community or individual levels and Governmental regulation.

It is important to be realistic about the degree to which the findings of case study research, such as that used in CUBOS, can safely be replicated beyond the precise conditions found in the original study sample. The fact that few tree species of global conservation concern were found in southern Honduras should not be taken to imply that conservationists should ignore Honduran dry forest in general: the CUBOS research did not examine whether there were globally rare or threatened species of animals or other plant groups present, and did not examine in any detail the valleys of interior of the country, where it is possible that endemism levels are higher due to the greater degree of isolation of the dry forest remnants there: indeed, they are home to an endemic species of *Leucaena* (*L. lempirana*) and an endemic hummingbird (*Amazalia lucidae*), which do not occur in the study area in south of the country. Neither should the evidence of tree husbandry practices in southern Honduras [2] be taken to imply that Boserupian processes of intensification of resource use and management will always automatically 'kick in' once certain levels of scarcity are reached.

Section 4. Improving Practice

The previous section showed, on the basis of the research results reported in the attached publications, that a number of common narratives regarding the MTDF and its inhabitants are, to greater or lesser degrees, either incorrect or excessively simplistic. It is clear that this situation is unhelpful: for example, inaccurate narratives regarding the severity and implications of deforestation, or the role of small farmers as agents of deforestation, can lead to scarce financial resources being spent in areas where they are unlikely to generate significant conservation benefits, and unnecessary restrictions being placed on farmers' livelihood support activities; excessive confidence in the 'farmer conservationist' narrative can lead to the degradation of natural resources and the undermining of the livelihoods of rural families who depend on them; and inadequate appreciation of the complexity of farmers' decision-making systems and livelihoods can lead to the promotion of interventions that are either ineffective or generate unintended negative impacts.

There are typically two reasons for this mismatch between narrative and reality. On the one hand, the research on which the narratives are based may be inadequately designed or executed, resulting in it capturing incorrect or misleading information, failing adequately to reflect complexity or context-specificity, or failing to make clear underlying assumptions and definitions. On the other, the narratives may be applied outside of the context in which they were originally developed and in which they were valid, leading to what Latour (1987) describes as "immutable mobiles".

A related and also problematic phenomenon is that of successive 'paradigm shifts' in academic thought (Kuhn, 1962), referred to at the end of section 2: existing paradigms may be rejected, despite potentially retaining some relevance, in favour of new ones that typically are diametrically opposed yet not necessarily more satisfactory. This phenomenon, described by (Wolf 1990:588) as an "*exercise in intellectual deforestation*", does not help us identify the best ways to address the needs and problems of the MTDF and its inhabitants.

Based on experiences gained during the execution of the reported research, and using the MTDF as a source of examples, this section examines a range of options for improving the processes whereby narratives are formulated and consequently lead to policies and actions. This route, which was introduced in Section 1, may be long and complex, and its outcome is highly dependent on how each of the links between its respective stages functions, and on the influences exerted on the process by those involved – these might include, for example, subjectivity in defining research priorities due to researchers' personal interests; selective communication of research results, or the use of weighted wording in research publications in order to emphasize particular issues; subjective selection of those research findings that are used to influence and justify policies; selective translation of policies into decisions (by executive and legislative arms of Government); and selective or ineffective implementation of decisions by the executive or the judiciary, due to weak capacities or weak political will.

Clarity and rigour in research

As shown in Section 3, the validity of narratives regarding farmers' relations with trees is highly dependent on the criteria used to define the extent to which conservation or deforestation are actually occurring. The concept of 'bioquality', developed by Hawthorne and Abu Juam (1995) and applied in the CUBOS research [3, 4, 5 and 8], is an example of a clear, relevant, objective and easily applicable measure of trends in natural resources. It is defined as the number of species of high global conservation priority present in any given site, and is preferable to the more commonly used measure, biodiversity (the total number of species present), which on its own would fail to flag up locations or land uses where the failure to implement adequate conservation measures could lead to permanent species extinctions [5].

The feasibility and validity of applying such simple measure of resource status are, however, limited by the social and biophysical complexity of ecosystems such as the MTDF. Despite its practical utility, the validity of the approach to defining conservation priorities, applied in the CUBOS research, was limited by the fact that

it focused only on tree diversity, while the degree to which the conclusions hold true for other groups of plants and for animals in the MTDF remains untested; and that it took a solely global perspective, which is justifiable if the sole priority is to avoid global extinctions but fails to take into account the national conservation priorities of sovereign countries [5, 8].

The difficulty of maintaining clarity and rigour is increased when one moves from the biophysical to the social sciences: the need to understand complex causal relationships – why people do what they do – calls for a relatively high level of reliance on 'soft' qualitative approaches than on 'hard' quantitative approaches. Although biophysical sciences are not inherently more rigorous than social sciences, there is a greater risk of imposing preconceptions and value judgements on analyses and descriptions of human behaviour in the social sciences than on purely biophysical parameters. The CUBOS socioeconomic research therefore aimed to strike an adequate balance between qualitative and quantitative approaches: this posed significant methodological and logistical challenges, but these were in the end rewarded by the rigour and depth of the insights that were gained [9]. Neither is "rigour" necessarily correlated directly with the degree to which quantitative approaches are used: the use of qualitative open-ended interviews in the household level studies served precisely to avoid the common risk of introducing subjective preconceptions into the definition of the questions included in quantitative questionnaires.

Broadening of research

The prevalence of 'immutable mobiles' and unhelpful abrupt paradigm shifts, such as those discussed in the preceding sections in relation to small farmers and trees, may largely be attributed to the monopolization of research by narrow 'epistemic communities' (*sensu* Haas 1992), located in centralized organizations such as international funding agencies, conservation NGOs and universities. The design and early implementation of CONSEFORH, for example, was highly dominated by a small epistemic community of technically focused foresters and botanists from DFID, the Department of Plant Sciences in Oxford and the Honduran Forestry

Development Corporation (COHDEFOR). The prevailing narrative among this epistemic community focused on the potential of Central American trees for the establishment of plantations in Honduras and worldwide, with seed and extension support provided, at least initially, by technical support agencies (in the Government or NGOs) and productivity maximized by tree breeding and genetic improvement (based on provenance and family selection) carried out by forest research institutions. This approach had limited applicability among the smallholders on the southern Honduran hills [1].

A logical counterpoint to this would be to open up such research processes to a broader diversity of epistemic communities, from different disciplines: a number of influential case studies that have been carried out in recent years (e.g. Connelly 1994, Leach and Fairhead 2000, Locatelli et al 2004, Ravnborg 2003, Swinton and Quiroz 2003 and Tiffen et al 1994) have helped to breach the horizontal disciplinary divides that have for long characterized research in the forestry and agriculture sectors (Chambers et al 1989). There has also been much progress in developing research methods that bridge disciplines and combine quantitative and qualitative approaches (Holland and Campbell 2005). CUBOS was another example of such an interdisciplinary approach to research [9], inasmuch as it brought together two distinct epistemic communities: on the one hand, the same combination of foresters and botanists that exerted such a strong influence on CONSEFORH and, on the other, social scientists from the Overseas Development Institute, with a prevailing interest in the potential of trees to support rural livelihoods and reduce poverty. This was something of a forced marriage, resulting as it did from a requirement by the manager of the Forest Research Programme of DFID that two separate proposals presented by these respective institutions be combined into a single project: it encountered resistance by some of those that had been involved in developing the original research proposals and who were concerned that their research focus would be diluted or diverted, and it also involved significant methodological challenges [9].

More scarce are studies that bridge vertical divisions between the local and the global, by considering simultaneously issues of (local) development and (global)

conservation: applying the “conservation biologist’s lens” (Vandermeer and Perfecto 1997) to the agroecosystem and at the same time analysing the livelihood implications of conservation. This is especially important with trees, given that typically these are important not only for local livelihoods but also by virtue of their global existence value and the global environmental services that they provide. Such an approach was the novelty of CUBOS [8].

As with the integration of quantitative and qualitative approaches, the integration of local and global issues in research implies methodological and analytical challenges. Again, however, this is likely to be compensated by the greater utility of the results for decision makers at different levels.

Democratization of research

The democratization of research (Forsyth 2003), involving ‘local’ actors who interact on a permanent basis with the resources in question, holds the potential to maximize the relevance of research questions, research results and resulting policies to diverse local needs and conditions. In the case of conservation, it has the potential to minimize the risk of unnecessary social impacts and to increase the likelihood of finding ‘win-win’ situations that combine conservation and development objectives. The CUBOS research was designed to achieve this, by generating reliable and objective findings that took into account local perceptions and knowledge, while avoiding the imposition of externally defined narratives regarding local needs and conditions.

The CUBOS research was participatory and democratic inasmuch as its social aspects borrowed research tools commonly applied in PRA, took care to avoid being guided by preconceptions (for example by using open interviews rather than questionnaires), was open and sincere about its aims and sought opportunities for synergies with local development NGOs; while the botanical research involved community-based ‘para-taxonomists’ and local NGOs, whose research capacities were thereby strengthened. It was not, however, as fully democratic or participatory as the ‘field school’ approach piloted most notably by the Food and Agriculture Organization of the United Nations (FAO) in Asia, or the “farmer first” approach

advocated by Chambers et al (1989), given that its objectives, agenda and methodologies were defined by external actors, who also controlled the ways in which the results were analysed and used. The qualified nature of the participation and democracy inherent in research such as that undertaken by CUBOS was justified by the fact that it aimed not only to address the interests of local stakeholders but also those of stakeholders worldwide in relation to the use and existence values of MTDF trees. As Chambers et al (1989) warn, 'farmer first' approaches should be considered as complements, rather than substitutes, to more conventional research: this is especially the case when such externalities are involved. This raises issues of environmental justice, which are discussed further in the concluding section of this essay.

There is also an issue of demand for democratization: it is only realistic to expect farmers to have the interest and will to participate in and own research when the issues in question are directly relevant to their livelihoods. There is likely to be little motivation for MTDF farmers to take into account the externalities of their actions if these remain as externalities and do not directly affect their own interests – how, for example, these actions affect the conservation status of globally rare or threatened species, or the functioning of hydrological processes that affect others. Sometimes, however, information on global environmental values can serve to guide policy and decision-making in favour of their interests and is, therefore, directly relevant to them: this was the case with CUBOS, where the finding that there were relatively few tree species of global conservation concern in southern Honduras implied that there was little justification in imposing restrictions on farmers in order to conserve biodiversity, and the finding in Oaxaca that there were large numbers of globally rare species was in accordance with the 'farmer conservationist' discourse, further substantiating their rights to manage their natural resources under traditional systems of tenure and governance.

Turner (2001:124) expresses reservations about the democratization of research, warning that certain scientific issues go beyond the competence of the public: "*we are faced with the dilemma of capitulation to 'rule by experts' or democratic rule*

which is 'populist' – that is to say, that valorises the wisdom of the people even when 'the people' are ignorant and operate on the basis of fear and rumour." The issues involved in relation to the conservation and management of trees in the MTDF are not in fact so complex as to be beyond the grasp of most small farmers and therefore to justify their exclusion from research, especially if presented to them in a language that is compatible with their cultural and educational backgrounds (while avoiding the infiltration, intentional or not, of non-neutral narratives into such presentations).

Improved communication and uptake of research findings

In the context of the process summarized in Figure 1, the practical utility of research, however well executed, ultimately depends on the degree to which it influences policies and actions. It is therefore still crucial to ensure that research results are communicated in an accessible manner to those who have the potential to influence the condition of the resource (such as technicians in Governments and NGOs deciding how to support farmers, members of executive and legislative branches of Governments deciding where to establish protected areas, or representatives of international funding agencies deciding how to support productive or conservation initiatives with implications for biodiversity or livelihoods).

Opportunities for communicating research findings are in theory increasing in proportion to growing worldwide access to the internet, and to the growing number of email listings that exist on development and conservation issues, which provide potted summaries of academic publications. In the Oaxaca study area, however, Gordon (2005) still found examples of NGOs being completely unaware of research, relevant to their work, being carried out by other organizations located geographically very close to them.

Improved communication and uptake of research results can also be achieved by investing further in presenting them in ways that are understandable and accessible – as in the one-page policy briefs prepared by CUBOS for national Government

agencies, NGOs and international conservation agencies[8]. The more information is pre-digested, however, to make it accessible to policy- and decision-makers, the more opportunity there is for researchers to impose constructivist interpretations on the messages. This would constitute a transfer of decision-making power to the researcher, from the actors formally entitled to make decisions – in the case of national and local Governments (despite their common shortcomings), these actors have normally been democratically elected to take such decisions, unlike the researchers.

Translating research findings into action

The practical utility of research results depends on them influencing not only discourse and policy, but also the concrete actions of those who interact with the resource and its inhabitants. In some cases, the gap between research, discourse and practice may be motivated by the desire to maintain power relations, as in the case of the landowning elites who dominate the political system in most of the countries where MTDF occurs. Such resistance to 'inconvenient truths' revealed by researchers is also evident in institutions, which may prefer to adhere to what Kaimowitz (2004) terms 'useful myths' when these reinforce the narratives which their institutions use to justify their actions. Some conservationists in Honduras, for example, expressed resistance to the suggestion by CUBOS that southern Honduras should not be prioritized for conservation investments in the MTDF due to the apparently low levels of bioquality there, as this was contrary to their discourses.

In cases where there is likely to be little spontaneous willingness to take on board and respond to research findings, a number of options are in theory available: in the case of the MTDF, however, their likely effectiveness is constrained by a number of factors that are characteristic of this ecosystem.

Firstly, there is the option of activism aimed at powerful elites or institutions. Resistance by local communities was successful in the case of the proposed Huatulco national park in Oaxaca, for example, and resulted in the establishment of

[8] http://www.research4development.info/PDF/Outputs/Forestry/R6913policy_brief_international.pdf

an alternative, community-managed model, that corresponded with the research findings regarding community-based governance [8] (although in that case it cannot be claimed that the research findings significantly influenced the activism). Conditions for successful activism are, however, less favourable in southern Honduras, where it might, for example, focus on achieving a more flexible regulatory framework for the use of on-farm trees: in contrast to coastal Oaxaca and even the pine forest areas elsewhere in Honduras (where there have been a number of examples of successful grassroots mobilizations in recent years), there are generally low levels of organization between the individual smallholders scattered across the MTDF agroecosystem there. In addition, with the exception of trees along stream sides or around water sources on which grassroots activism there has largely focused (for example by 'Nature Defence Committees' [1]), the nature of the MTDF agroecosystem means that the environmental issues there are less clear, understandable or easy for activists to identify with than in more 'conventional' closed forests.

Secondly, there is the option of changing resource managers' behaviour through 'business-based' approaches – either punitive, through product boycotts, or motivational, through price premiums for products which are generated in accordance with progressive environmental and social discourses. Such approaches have been widely tried in pine and humid broadleaved forests throughout Mesoamerica (e.g. Bray et al 2002). There are, however, few if any comparable experiences in the MTDF, where their potential is likely to be limited by the fact that this vegetation type yields relatively few products that currently or potentially enter into global markets in significant volumes [8].

In other cases, the barrier to translating research findings and narratives into action may not be active resistance to change as a result of vested interests in the status quo, as discussed above, but rather a lack of demand for such findings. National institutions such as the Ministry of Environment and Natural Resources (SERNA) and the Institute of Forest Conservation and Development (ICF) in Honduras typically set conservation priorities at national, rather than global levels, using

criteria such as gaps in the inclusion of ecosystems in national protected area systems, the risk of species extinctions at national level, and economic (rather than biological) extinctions of species: there is little evidence that research findings regarding global conservation priorities are of interest them. The third option is therefore to make global issues of interest to such actors, by providing funding that is conditional on such issues being considered or promoted: this is the approach of the Global Environment Facility (GEF), whose support is principally aimed at conserving global environmental values but also aims to generate tangible national benefits, and was also the case with the WWF in Oaxaca, seen in Section 2, which provided financial support to the initiatives of local NGOs subject to an overall objective of global biodiversity conservation.

A fourth option is to support the development of an institutional culture or mechanisms, in Government institutions or NGOs, for taking on board research findings, keeping staff up to date with recent developments in scientific literature or involving them in research. The existence of an unmet need for such an approach, which is discussed further below within the context of adaptive management, was shown by the difficulty experienced by CUBOS in obtaining real commitments from institutional partners in Honduras to participate in the practical aspects of research, despite their initial expressions of interest [9].

Promoting local participation in conservation and development

Earlier in this section, the need for local participation and democracy in research was highlighted, as long as this does not limit the scientific rigour and objectivity of research findings or its relevance to global, as well as purely local, interests. It is evident from the discussion above, of strategies for improving the translation of research results into action, that there is a similar need for increasing local participation in the implementation of conservation and development initiatives. As discussed in Section 2, this may be justified from either a ‘rights-based’ perspective (which argues that local people have an intrinsic right to continue to inhabit and use the lands to which they have traditionally had access) or a ‘utility-based’ perspective (based on their potential to complement the activities of outside conservationists). It

has also been seen that there are a number of promising examples in the region of such participatory approaches, such as the communal structures for local decision-making and regulation found in the communities studied in coastal Oaxaca [8] and the 'Nature Defence Committees' established in a number of communities in southern Honduras [1], as well as the establishment of farmer field schools and local agricultural research committees, supported by NGOs in southern Honduras.

In much of the MTDF, however, there is still a very long way to go before small farmers, or the local communities to which they belong, are allowed full and real participation in conservation and development initiatives. Agricultural and forestry extension is still dominated by conventional top-down approaches, and there is much evidence of 'pseudo-participation', such as the formulation by individual NGOs of village-level committees specific to their actions and interests, in which attendance is motivated by financial or other incentives rather than genuine commitment to, and prioritization of, the issues by the community members themselves [8]. This is akin to the 'new tyranny' of which Cooke and Kothari (2001) warn, which provides a façade of participation while in reality serving only to 'sweeten the pill' of pre-determined agendas of external actors.

A priority for researchers and practitioners in the MTDF in the future, therefore, should be to continue the processes of systematization and dissemination of positive experiences of local participation, such as those mentioned above, and subsequently to support their participatory validation and their adaptation to site-specific variations in social and biophysical conditions. This should again be associated with the progressive modification of institutional cultures in order to generate increased acceptance of participatory approaches. As discussed above in the case of research, such moves towards increased participation in the implementation of conservation and development initiatives should be tempered by realism (a point stressed in much of the literature reviewed in Section 2) and recognition of the need to safeguard global, as well as purely local, interests.

Monitoring

As seen in Section 3, the condition of the MTDF and its inhabitants is affected by a wide range of social and biophysical factors. Some of these have shown unexpected trends in the past, and it is likely that they or others may behave in a similarly unpredictable way in the future. Under such conditions of uncertainty, there is a risk of narratives progressively becoming inaccurate and irrelevant as circumstances change around them – of 'mobiles' (Latour 1987) becoming immutable through time as well as across geographical locations. High priority should therefore be accorded in the future to monitoring trends in variables that are likely to affect the status of the MTDF, in order to avoid falling into this trap. Examples of factors to which such attention should be paid in the future include the following:

- *Crop prices:* historically low prices for maize and beans explain, at least in part, farmers' willingness to retain trees in fields and their limited motivation to invest in the mechanical grubbing out of live stumps from the southern Honduran hills [2], and have also contributed to the emigration of many economically active members of the population from this area, with corresponding implications for the availability of labour for agricultural production [7]; crop prices have shown unexpected fluctuations over recent years, however.

- *Demography*: population growth in much of the MTDF has for long been exponential [8], a factor which has at least partly explained the progressive subdivision of agricultural plots in southern Honduras; it is unclear whether, and if so at what point, this historical trend will be reversed by emigration, and what the implications of this will be for the demand for land and tree products, or for rural labour supply.

- *Remittances*: the economies of rural households throughout much of Latin America have become highly dependent on economic remittances from emigrant family members over recent decades; it is as yet unclear to what effect declines in these, such as those that have occurred in recent times due to the global economic crisis, may affect the overall viability of rural

livelihoods and lead to accelerated processes of emigration from the countryside.

- *Climate*: the agronomic viability of the agricultural production systems within which tree husbandry practices in the MTDF are enmeshed is highly dependent on the precise timing and magnitude of rainfall, which may vary in the future as a result of global climate change.

Equally important to study in the future, in addition to the direction and magnitude of changes in these factors, are the implications of such changes, and the ways in which they interact. Hecht et al. (2006) attribute the forest resurgence that they detected in El Salvador largely to the agrarian reform programme implemented there: however, as discussed in the previous section, the effects of agrarian reform in Honduras have been very different. Likewise, it is by no means clear whether, under the conceivable scenario of a collapse of existing livelihood and farming systems on the southern Honduran hills as a result of climate change, reductions in labour availability or declines in remittances, there would be a resurgence of forest cover (as has occurred in Puerto Rico due to rural-urban migration, Aide et al 2000, Grau et al 2003) or a switch to less climate dependent and labour intensive production systems such as extensive cattle ranching, which would result in a further loss of forest cover.

The task of monitoring should be shared by researchers and practitioners (defined as members of Government institutions and NGOs engaged in initiatives related to development and conservation of the MTDF), as well as the inhabitants of the area who interact directly with its trees and other aspects of the environment, and is likely to require capacity development and, at least in the short or medium terms, external facilitation.

Adaptive management

Closely related to the issue of monitoring is that of adaptive management, whereby the results of monitoring are fed on a continuous basis into decision-making. Armitage et al (2008) stress the importance of such ongoing assessment, reflection

and feedback for the management of systems that have high levels of 'social-ecological complexity' and where 'command and control' approaches to resource management are of limited applicability – both of which are characteristics of the MTDF. In their proposed model of 'adaptive co-management' (which merges the principles of adaptive management and co-management), adaptive management ceases to be the exclusive domain of projects or of the institutions of Governments and NGOs, and is democratized in the same way as has been proposed above with research.

This idea of empowering and building the capacities of local people to analyse, monitor and respond to their circumstances on a continuous basis is in fact inherent in the literature on participatory approaches to development that emerged in the 1980s and 1990s: it echoes the call of Chambers (1994) for 'flexible and continuous learning and adaptation' in the application of Participatory Rural Appraisal (PRA). Much of the agricultural and forestry extension support currently provided in the MTDF by Government agencies and NGOs is, however, still dominated by more conventional vertical approaches featuring technology transfer, rather than the development of farmers' capacities for learning and adaptation; changing this approach will require not only changes in institutional operating mechanisms but also a change of mindset on the part of extension agents, which in turn will depend on modifications to the curricula of the institutions that train them, a process which is likely to take several decades to yield significant results in the field.

The essence of adaptive management, whether at the level of institutions and projects, or at the community level as in the concepts of adaptive co-management and PRA, is that research is not only democratized but also de-compartmentalized: for members of institutions, project staff and community members to become researchers and for research to be a continuous process. Political pressures to achieve short term quantifiable impacts in projects work against this: often, the baseline studies that are necessary to allow projects to monitor and therefore adapt to their progress are either poorly done, irrelevant or not done at all, and progress is

only evaluated according to immutable criteria that are defined during project design, regardless of whether these remain relevant over time.

The 'project' model that dominates how development and conservation support is provided in the MTDF, involving the injection of time-constrained and isolated packages of resources, appears to be anathema to this idea of adaptive management. It is illusory to expect this model to disappear, at least in the short or medium terms, given the continued need for local initiatives to be supported by external funds and for the providers of such funds to place time limits on their execution and on the corresponding generation of impacts; priority should therefore be placed on defining how to insert adaptive management into this model, rather than rejecting the model. In addition to ensuring that the situation analyses, on which project designs are based, reflect as closely as possible the needs and conditions of their human and biophysical environments (through broadened and democratized research, as suggested above), it is necessary for key aspects of these analyses to be updated continuously throughout the life of any such project and, crucially, for mechanisms to be applied allowing this flow of interdisciplinary and qualitative/quantitative information actually to be taken into account in project decision making. The prime responsibility for achieving such changes lies with the agencies that fund such projects, who need to adapt their project management and monitoring and evaluation strategies accordingly, and ensure that such changes are also carried out by national and local level project implementers.

Conclusions

It is evident from the discussions in this section that there is much room for improvement in the way that research is related to conservation and development practice, in order better to serve the needs and conditions of the MTDF and its inhabitants. A number of aspects of the methodology applied in the CUBOS research were favourable in this regard: the research was scientifically rigorous and at the same time broad and inter-disciplinary in scope – it was particularly innovative inasmuch as it bridged the local/global divide as well as horizontal divides between disciplines and sectors. It was also as democratic and participatory

as possible, within the constraints of the need to ensure scientific rigour and to meet the specific research objectives imposed by the funding source. These requirements of rigour, clarity and focus are indeed likely to limit the level of methodological improvement that is possible in comparable initiatives in the future, at least on the part of researchers.

Where there is more need and opportunity for improvement is in the later stages of the pathway linking research to action. In addition to the 5 peer-reviewed articles, 3 book chapters, one book and several conference presentations that were generated by CUBOS, two policy briefs were produced with the specific aim of communicating research findings clearly to policy makers, however there is little evidence to date of them having had concrete impacts on the ways that development or conservation agencies operate. This suggests that opportunities for further improvements in the process are largely in the hands of the 'clients' of research findings, such as conservation and development agencies, rather than among researchers (as conventionally understood) themselves. On the one hand, those working in such agencies need to become researchers themselves at the same time as being practitioners, by observing and analysing the biophysical and social environment in which they work and adjusting their actions, and the policies and strategies of their institutions, accordingly. On the other, these institutions and their members need to be more open and responsive to the findings of others, in the form of research results and institutional experiences. This requires modifications not only to institutional culture and design but also to the way that conservation and development practitioners are trained, with more emphasis on the development of capacities for critical analysis than on rote learning.

Section 5. Challenges for the future

The previous section examined opportunities for improving practice among researchers and practitioners, in the fields of conservation and development, in order better to serve the needs and conditions of the MTDF and similar ecosystems elsewhere. This concluding section reflects on some issues that are likely to be more intractable and to continue to pose major challenges for researchers and practitioners in the region, in the future.

A major unresolved issue, which cuts across many of the topics discussed in the preceding sections, is the continued subjection of small farmers in the MTDF to a inequitable power relations – the "*multi-directional subjection to powerful outsiders*" posited by Shanin (1973:63-64) as one of the defining characteristics of the peasantry worldwide. These include unfair labour relations when undertaking seasonal off-farm work, exclusion from fair participation in markets for their produce and marginalization from access to productive land (Durham 1979, Stonich 1989). They are in addition subject to inequitable power relations with Governments, local and international NGOs and international funding agencies: national Governments have the physical ability to impose regulations on them, while funding agencies have the financial power to impose their agendas on farmers, either directly or through the NGOs and Governments with which they interact. These power inequities are not favourable for the application of the democratized and participatory approaches to research and conservation discussed in the previous section.

Modifications to power relations are more easily proposed than implemented. Conditions of inequality and marginalisation of farmers by local elites have persisted throughout Central America despite attempts to correct them during the period of social and political upheaval in the 1980s and 1990s (Jansen 2000), and to modify the power relations between international funding agencies, Governments, NGOs and farmers to any significant degree would require major reengineering of the machineries of development and government in MTDF countries. Difficulty is added

by the fact that the MTDF stakeholders are many in number and diverse in nature, and that the relations between them are complex, multi-directional and dynamic [7]. The question of how to address skewed power relations is particularly complex in the case of conservation, as the ideal balance of power to be sought depends on the relative weights that one assigns to the rights and interests of these different stakeholders, from local to global levels.

This brings us to the issue of environmental justice. The exercise of financial power by international funding agencies in order to promote their conservation agendas, discussed in the previous section, opens up the risk of accusations of 'environmental colonialism' (Nelson 2003), infringing on the sovereign rights of national Governments to define their own conservation priorities. Issues of social justice and equity are particularly complex in the case of the conservation of globally useful or rare trees, such as those that occur in the MTDF, as this involves both person-to-person and intersocietal relations (Sen, 1999) – the former in the form of the environmental services and power relations that link farmers to more powerful actors at local and national level, and the latter in the form of the relations between developing countries such as Honduras and Mexico that host biodiversity, and other countries worldwide that potentially benefit from its existence.

Added complexity is introduced by the fact that these relations do not necessarily correspond to vertical power structures – both the Mesoamerican farmers that host MTDF biodiversity and many of the farmers worldwide that have the potential to benefit from it are poor and weak – and so are not easily resolved by shifting the balance towards the weaker party. This gives rise to a potential dilemma: if the realization of the potential of Mesoamerican trees to contribute to the livelihoods of the rural poor elsewhere in the developing world [1] were dependent on the imposition of restrictions on the livelihood support activities of Mesoamerican farmers, which course of action should be taken: to impose restrictions on the basis of the narrative of the rural poor worldwide as victims of poverty, or to oppose such restrictions on the basis of the narrative of Mesoamerican farmers as potential victims of conservation?

Neither is democratized and participatory research likely to lead to an optimal outcome in terms of the distribution of costs and benefits between all stakeholders, at local and global levels, if the democracy only extends to local stakeholders: there is likely to be little motivation for farmers to adopt a positivist approach to research on priorities and strategies for conservation when their wellbeing depends directly on the results. How would farmer-researchers in southern Honduras and Oaxaca have reacted if it had emerged that their livelihood support activities were resulting in the loss of globally rare tree species – by proposing restrictions on their own activities for the greater good?

The balance that should be struck between the interests of diverse stakeholders, for example those related to the conservation and use of MTDF trees, is not a decision that can or should be taken by researchers, such as this candidate. Politicians, at least in theory, exist in order to balance the interests of their diverse constituents; however, as seen in the previous section, they often have vested interests in favouring one stakeholder group over another, especially in Latin American countries where politics are normally dominated by landowning elites. Their role in relation to global environmental issues, such as the conservation of globally useful or rare tree species, is also limited by the fact that their influence and interests are principally located at the national level where their constituents are found.

The ideal, in theory, would be to develop a perfect methodology for economic valuation of the implications of all alternatives on all stakeholders, and then to choose the option with the highest net positive outcome. Economics, however, is an imperfect science, particularly in the case of tropical forestry, and highly dependent on the weights that are assigned (typically in a subjective manner) to different elements of the environment, to the interests of different people and to the timeframes within which costs and benefits are experienced. Flint (1991) highlights the difficulty of deciding on the values that are to be maximised when defining biodiversity conservation priorities, and the different priorities of different actors: this would be further complicated if the costs, as well as the benefits, of conservation were included in the equation. Sen (1999) recognizes the difficulties

and limitations of the approach of 'grand universalism', which seeks to balance in an equitable manner the interests of all stakeholders worldwide, but also considers an exclusively national focus as too narrow to allow many policy issues reasonably to be addressed. More appropriate would be the alternative approach, suggested by Sen (1999:122), of posing the issue of justice and fairness *"in several distinct though interrelated domains involving various groups that cut across national boundaries"*.

Conclusions

As was made clear at the end of Section 2, this essay has not attempted to generate simple solutions, or to propose a ringing new grand narrative, "*taking an ax to the knees*" of those who have proposed earlier ones (Greenberg and Park, 1994:1). It is in practice futile to expect that any generally applicable simple truths will ever be found that adequately capture such a complex entity: no single depiction is likely to be wholly and universally true, yet at the same time most depictions have some truth in them. As Upton et al (2008) warn: *"…relationships between poverty and conservation action are dynamic and locally specific… critics of conservation who build upon local case studies to argue that protected areas make a significant contribution to poverty risk exaggerating the scale of the problem. However, conservation advocates also need to temper their enthusiasm. Outcomes in which both poverty alleviation and conservation goals are achieved may be possible in specific circumstances but clear choices will often need to be made between conservation and livelihood goals*." These issues are particularly complex in the case of the MTDF, given the diversity of its human inhabitants and stakeholders and their close and complex links with the tree and forest resources, the major geographical differences that exist in the conservation status and global conservation priority of its vegetation, and its position as an inseparable part of a global system of costs, benefits and interests, ranging from fields and fallows in Mesoamerica where MTDF tree diversity originates, to largely similar farms in Africa and Asia where many of the same trees are used as exotics by small farmers.

In such a complex system, with such a wide diversity of interested parties, it will never be possible to please everyone. Those with the opportunity to influence how

the MTDF is managed – such as representatives of national Governments or international conservation and development agencies – may therefore have to opt for the narratives, and corresponding policies, that represent what they consider to be the best possible balance of cost and benefits, without necessarily leaving everyone better off. The role of researchers should be to provide such decision-makers with as much information as possible with which to do this – on, for example, the conservation status of different species, or the potential livelihood implications of alternative conservation strategies – while making clear the limitations of the replication domains of their findings, and the degree to which the research that generated the findings is influenced by social constructions. This was the intention of CUBOS [8].

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Annex 1: Summary of published work

1. **Reconciling genetic conservation and local needs in the dry zone of Central America.** Barrance, A.J. (1997). *Commonwealth Forestry Review* 76(2), 1997, 98-102. Peer-reviewed journal article

This article queried the appropriateness of some approaches applied by external agencies, in this case aimed at simultaneously conserving genetic diversity and supplying genetically improved tree seed for plantations. The publication mentions an inherent incompatibility between the goals of conservation and development, given that the former presupposes the maximization of genetic diversity in *ex situ* plantations whereas the latter requires a narrowing of the genetic base in order to provide selected material for specific end products. It also highlights a difference between technical foresters' views of how tree populations should be improved, disseminated and managed, and the reality of the needs and conditions of peasants. Mesoamerican peasants are portrayed as operating within complex farming and livelihood systems, to which externally actors should adapt. The publication also introduces the distinction between 'global' and 'local' priorities: in addition to introducing externally-formulated ideas, external agencies may represent additional interest groups whose needs may not be the same as, or compatible with, those of local peasants.

2. **Trees and farming in the dry zone of southern Honduras I – campesino tree husbandry.** A.J. Barrance, L. Flores, E. Padilla and J.E. Gordon (2003). *Agroforestry Systems* 59(2), 2003, 97-106. Peer-reviewed journal article.

This was the first of a series of publications that emerged from the CUBOS research project. The central narrative in this publication is that of the peasant as conservationist: as such, it echoes the findings of Publication 1 regarding the significance of *circa situm* conservation and conservation through use in southern Honduras. The research on which this publication was based aimed to respond to the call by Chambers (1995) for an understanding of farmers' realities as defined by them, rather than by external actors.

3. **Trees and farming in the dry zone of southern Honduras II – the potential for tree diversity conservation.** J.E. Gordon, W. Hawthorne, G. Sandoval and A.J. Barrance (2003). *Agroforestry Systems* 59(2), 2003, 107-120. Peer-reviewed journal article.

This article brings a global conservation perspective to bear on the tree husbandry practices described in its partner article, on the basis of the results of botanical sampling carried out by the lead author: the "conservation biologist's lens" that Vandermeer and Perfecto (1997) suggest be applied to agroecosystems.

4. **Are rare species useful species? Obstacles to the conservation of tree diversity in the dry forest zone agro-ecosystems of Mesoamerica**. J.E. Gordon, A.J. Barrance and K. Schreckenberg (2003). *Global Ecology & Biogeography* 12 (1), 2003, 13-19. Peer-reviewed journal article.

5. **Assessing landscapes: a case study of tree and shrub diversity in the seasonally dry tropical forests of Oaxaca, Mexico and southern Honduras.** J.E. Gordon, W. D. Hawthorne, A. Reyes-García, G. Sandoval, and A. J. Barrance (2004). *Biological Conservation* 117 (2004) 429-442. Peer-reviewed journal article.

6. **Prospects for *circa situm* tree conservation in Mesoamerican dry forest agro-ecosystems.** Boshier, D.H., Gordon, J.E. and Barrance, A.J. (2004). In: Biodiversity Conservation in Costa Rica; Learning the Lessons in a Seasonal Dry Forest. G.W. Frankie, A. Mata and S.B. Vinson (eds). University of California Press, Berkeley, California. Book chapter.

These three publications present similar analyses of the global implications of tree and forest management practices carried out by farmers in the Mesoamerican dry zone, broadening the geographical scope to include the second study area covered by the CUBOS research, in Oaxaca, Mexico. The importance of sound and objective analysis, in the definition of conservation priorities and the identification of conservation opportunities, which is stressed in this article, mirrors that which is called for in the earlier publications, with reference to the definition of development strategies. This is argued from the viewpoint of both the external conservationist, in order to avoid wasting

scarce funds on protecting biota that are not global priorities for conservation, and of the peasant, in order to avoid imposing on him or her unnecessary restrictions aimed at conserving such biota. The inclusion of the Mexican study area in these later three publications introduces a new element, that of the community, rather than the individual peasant, as the interlocutor and agent of conservation, constituting a further contribution to the literature on community-based conservation and common-property resource management (e.g. Orstom 1990).

7. **Trends, cycles and entry points in the dry forest landscapes of southern Honduras and coastal Oaxaca.** A.J. Barrance, J.E. Gordon and K. Schreckenberg (2006). In: Savannas and Dry Forests – Linking People with Nature. J. Mistry and A. Berardi (eds). Ashgate. Book chapter

This book chapter proposes alternative approaches to analysing the relationship between man and the environment in the Mesoamerican tropical dry forest, with the location of man as an integral element of the natural environment (introduced above in relation to Publication 2) as a central tenet, in keeping with anti-essentialist thinking (Escobar 1999). The chapter, which was based on the results of the CUBOS project, goes beyond the linear cause-effect trees presented in Publication 2 when discussing the functioning of the dry forest landscape: on the one hand, it introduces a further level of complexity into such causal relationships, by recognising the existence of self-perpetuating 'spirals', or vicious circles, and self-neutralizing 'loops' and, on the other, it shows how landscape units and stakeholders relate to each other in hierarchical terms, following the model of 'hierarchical patch dynamics' proposed by Wu and Loucks (1995). These approaches introduce an additional element of utility to the analyses presented in the other publications: the recognition of the peasant at the centre of a hierarchical structure of factors and stakeholders, and of the existence of 'entry points' into the causal chains, spirals and loops that determine the nature of the landscape, permit the formulation of strategies for the effective intervention by external actors in the landscape.

8. **Conservation Through Use: Lessons from the Mesoamerican Dry Forest.** A.J. Barrance, K. Schreckenberg and J.E. Gordon (2009). Overseas Development Institute, London.

This book provides an overview of all of the results of the CUBOS research project, and specifically discussed in detail the concept and applicability of the concept of conservation through use, which was introduced in Publication 1 and which fundamentally concerns the relationship between humans and their environment, which is the central theme of this essay. The analysis presented in that book responds to pleas by authors such as Freese (1997) for realism in relation to this approach which had generated such interest. In common with Publication 1, the book recognises the diversity of stakeholders with interests in the goods and services provided by ecosystems such as the Mesoamerican tropical dry forest, the diversity of such uses and the consequent diversity of levels of utility of the concept of conservation through use.

9. **Trade-offs between management costs and research benefits: lessons from the forest and the farm.** Schreckenberg, K., Barrance, A.J., Degrande, A., Gordon, J.E., Leakey, R., Marshall, E., Newton, A. and Tchoundjeu, Z. (2005). In: Methods in Development Research: Combining Qualitative and Quantitative Approaches. J. Holland and J. Campbell (eds). Centre for Development Studies, University of Wales, Swansea. ITDG Publishing.

Finally, this book chapter explores the methodological challenges, identified during the course of the CUBOS project, associated with conducting research into the relations between man and the non-human environment, and between local and global values. It highlights in particular the difficulty of coordinating and integrating the work of researchers from the social and biological sciences and of bringing together and presenting the results of their work in a useful manner.

Annex 2: Supporting Publications

Reconciling genetic conservation and local needs in the dry zone of Central America

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SUMMARY

The genetic resources of the dry forest zone of Central America are of great potential value for development programmes on marginal sites throughout the tropics. The opportunity for realising this potential is being jeopardised by deforestation. Innovative approaches to genetic conservation and to seed supply are required to address this problem, while taking into account the needs of the rural population and the national economies of the region. The key to conservation lies in recognising small farmers as the managers of genetic resources. To manage these resources in a sustainable manner, they need assistance in the form of organisational support, and the promotion of practices of 'conservation through use' which provide them with positive benefits. Seed supply should be planned on the basis of an objective assessment of small farmers' needs: these may differ significantly from those of industrial consumers.

Keywords: Central America, dry forest, *ex situ* conservation, conservation through use, seed supply.

THE GENETIC RESOURCES OF THE REGION

The dry forest zone of Central America contains many native tree species which are of great potential value for development programmes throughout the tropics. Notable examples are *Albizia caribaea, A. guachapele, A. saman, Bombacopsis quinata, Caesalpinia eriostachys, Cedrela odorata, Cordia alliodora, Enterolobium cyclocarpum, Gliricidia sepium, Leucaena salvadorensis, Mimosa tenuiflora* and *Swietenia humilis.* As a result of the region's range of topographical, climatic and edaphic conditions, many of the species and populations that occur contain great diversity and are particularly well suited to the marginal situations to which forestry and smallholder agriculture are commonly relegated throughout the world.

These genetic resources are currently suffering severe degradation. It is estimated that between 1970 and 1980 the region lost around 15% of its natural forest cover, equivalent to an annual loss of 343,000 ha (Leonard 1987). In addition to this reduction in gross forest area, the remaining forests have suffered depletion due to piecemeal felling and the suppression of natural regeneration by fires and agricultural activities. This has resulted in the loss of valuable populations and has had a severely dysgenic effect on the remaining resources. In many areas forest cover is now restricted to small remnants and individual trees within an environment of agricultural activity and degraded scrubland. Regeneration is often scarce or non-existent, and the increasing distance between the remaining trees reduces opportunities for pollen exchange and thereby limits their ability to reproduce successfully.

The causes of the forest degradation are various and interrelated. The expansion of cattle ranching, principally by larger landowners, has resulted in wholesale forest clearance. Trees are felled for timber, both on a commercial scale by the region's forest industry, and on a piecemeal basis, often illegally, to supply wood for small-scale artisanal furniture workshops, building material and fuel. Frequent dry-season fires severely limit natural regeneration.

THE HUMAN POPULATION

Many of the rural population of Central America are subsistence farmers, with few economic resources and limited access to adequate education, health care and other basic facilities. The economic pressures faced by the national governments of the region, meanwhile, have led to an emphasis being placed on the development of export-orientated cash crops; these typically dominate the more fertile areas and as a result the rural poor have found themselves increasingly marginalised on to steep unproductive land. Many small farmers lack adequate land for their subsistence needs or, if they have access to land, lack security of tenure. Agrarian reform programmes have had variable success, due largely to problems with providing the levels of technical support required by small farmers to enable them to make the transition to commercial agriculture. The insecurity of land tenure experienced by many farmers does not encourage them to invest in good soil management and

consequently productivity is generally low. There are, however, a large number of non-governmental organisations (NGOs) and Government projects working with small farmers and co-operatives in the region, in the promotion of sound soil management practices, sustainable agriculture and tree planting.

There is therefore a dual challenge in the Central American dry zone: to conserve the genetic resources of the region to allow them to be used for the benefit of developing countries worldwide; and to contribute to the satisfaction of the development needs of the national economies and of the rural populations of the region. The aim of this paper is to examine the options available for reconciling these two priorities.

OPTIONS FOR GENETIC CONSERVATION

In situ conservation aims to preserve trees as part of wild populations. It preserves both the population and the evolutionary processes that enable it to adapt (CMGGR 1991). 'Wild' in the context of the Central American dry zone includes populations that have been substantially degraded and altered by human activity: the selection pressures acting on these populations may be very different from those that prevail in intact ecosystems.

The classic means of achieving *in situ* conservation is by establishing strict reserves, which protect ecosystems in an undisturbed state. This removes the risk of losing species or populations before their potential value is fully understood, or disrupting crucial interspecific relationships. It also preserves natural selection pressures, and thereby perpetuates natural patterns of diversity. Janzen (1986) however estimates that only 0.08% of the dry forest ecotype is currently included within formal protected areas. An important example of a dry forest protected area is the Guanacaste National Park in Costa Rica (Janzen 1986); however this reserve is largely concerned with the rehabilitation of already-degraded dry forest.

The main limitation of the strict reserve approach is the need to take large areas of land out of production. In most of the dry forest zone of Central America, the levels of rural poverty and agricultural pressure make this infeasible. The attempts which have been made to date at establishing and protecting strict reserves in the region have often met with limited success. Cerro Guanacaure, one of the few sizeable dry forest remnants left in the south of Honduras, for example, suffers continually from illegal piecemeal tree felling despite the best efforts of Government agencies and local NGOs, and the presence of armed guards.

A more effective and sustainable approach for protecting the small patches of remnant forest within which much of the region's genetic resources are found may be to devolve the responsibilities for protection to local people. NGOs can play a key role in this regard, by increasing the awareness of local people of the value of forest remnants for water catchment protection and as sources of forest products, and by assisting them to organise at village level. An example of such an NGO is PROCONDEMA (Environmental Conservation Promotion and Training Programme), which is fostering the establishment of Nature Defence Committees (Comités por la Defensa de la Naturaleza) in a number of communities in the south of Honduras.

Another approach is to recognise that human activity is inescapably a part of the ecosystem of the dry zone, and to seek ways to use it as a positive force for conservation. The active planting of indigenous trees by small farmers can help to counteract the decline of degraded populations (Gibson 1993), while providing positive benefits to local people. Many extension organisations already exist in the region through which this may be promoted. While many native trees may not equal the growth rates of the best exotics, they have the advantages that seed is readily available and their characteristics and products are generally familiar to local people. An important factor limiting their use at present appears to be that many extension workers are currently only familiar with a narrow suite of exotic species. The risk that natural patterns of population diversity will be disrupted and diluted if non-local provenances of native species are used may have to be accepted if this is the only means of ensuring *in situ* conservation at the species level (Hellin and Hughes 1993).

In Costa Rica, the Fundación Pro-Iguana Verde has shown that the farming of iguanas (*Iguana iguana*) in forest remnants is an effective form of 'conservation through use' which provides farmers with a cheap and readily-available source of protein, and a source of cash income. At the same time it provides an incentive to protect and regenerate forest areas, as habitats and food sources for the iguanas (Werner, pers. comm.[1]).

Ex situ breeding plantations are less vulnerable to the forces of deforestation than *in situ* populations, and the genes which they conserve are more readily accessible for management and potential use (CMGGR 1991). They tend, however, to distort natural patterns of diversity, and fail to conserve ecological systems and interrelationships. Hellin and Hughes (1993) also argue that it would be in the long-term better interests of local people to address the problems and contentious issues associated with *in situ* methods rather than to side-step them by conserving genes *ex situ*.

Ex situ plantations may impose considerable demands on limited land resources and require intensive management, which may be difficult to guarantee in the long term. The CONSEFORH project in Honduras has attempted to overcome these problems by the use of Breeding Seedling Orchards (BSOs). These combine *ex situ* conservation and seed production for consumers' needs within the same plantation. They conserve between-family diversity by including and retaining a large number of families, family identity is retained throughout, in order to permit further breeding at a later date, half-siblings are arranged in family groups in order to facilitate within-family selection, and family groups

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[1] Dagmar Werner, Fundación Pro-Iguana Verde, San José, Costa Rica.

are replicated so that the plantation can also function as a progeny test (Gibson 1993). By attempting to fulfil various objectives in one stand, some degree of compromise of each of these objectives is inevitable. Diversity is narrowed to some extent by within-family selection; the level of genetic improvement achieved is less than the maximum possible; and the statistical comparisons of progeny performance are compromised by selective thinning.

The level of compromise involved in the BSO design described above arises from the attempt to select populations and species for a narrow range of traits in order to satisfy the needs of specific end-users. For many farmers, however, diversity rather than selection is what is required, in order to assure stability of production and the ability to produce a wide range of products (Simons, MacQueen and Stewart 1992). The needs of such farmers would best be met by plantations which are managed to maximise diversity, with a broad family base, maximum mixing of families, and systematic rather than selective thinning. Such plantations would coincide very closely with the ideal from the point of view of conservation.

OPTIONS FOR SEED PRODUCTION

It is appropriate to supply farmers with seed from external sources when seed of the species concerned cannot be collected locally, or when improved material is required. This provides the opportunity for introducing material which has been selected and bred to improve yields and other characteristics. It depends, however, on the consumer having the means of obtaining the seed: this requires seed to be appropriately priced or subsidised and efficient distribution mechanisms must exist.

Conventional seed orchards may be appropriate for supplying the needs of plantation managers who are able fully to realise the benefits accruing from tree improvement and to manage the risks associated with reduced diversity. They have considerable potential to generate income, given the prices commanded by the high-quality seed; they require high standards of design and management, however, and the seed which they produce may be too expensive for many consumers.

Compromise BSOs, as described above, may meet the needs of those who require reasonably-priced seed with a moderate degree of selection. An alternative means of obtaining large quantities of selected seed in a short time and at a low cost is to convert existing plantations into seed stands by selective thinning. This has been carried out in plantations of *Gmelina arborea* in Costa Rica (Barquero Pérez, 1987) and in *Gliricidia sepium* plantations by the MADELEÑA project in Honduras. The quality of the seed obtained in this way depends, however, upon the reliability of the phenotypic selection and upon the origin and genetic diversity of the material of which the stand is composed. Pure conservation plantings, meanwhile, can be used to provide seed which, although unimproved, maintain the levels of diversity favoured by small farmers.

Local collection of seed by farmers, from wild, naturalised or planted populations is more likely to be achievable and sustainable, as it avoids the need for organisation, communication and expenditure. The sale of locally-collected seed to seed banks, commercial dealers and extension agencies may also provide local people with a source of income, as well as increasing their perceptions of the value of seed-bearing trees and thereby providing a motivation for their conservation. Large quantities of *G. sepium* seed, for example, were collected by villagers in the Linaca valley of southern Honduras for sale to a forestry extension programme in Haiti, under the coordination of the Vecinos Mundiales (World Neighbours) programme. In order to avoid the risk of inbreeding depression as a result of people collecting from a limited number of possibly related trees (Simons, pers. comm.[1]), the quality of collections should be carefully monitored, or more simply seed may be amalgamated from a number of different collectors.

SPECIES CHOICE

Conservationists, extension organisations, local people and host country governments may have different preferences for the species to which they consider that priority should be given by breeding programmes. The interests of both conservationists and international development agencies would best be served by focusing on internationally important multi-purpose trees which are under threat of genetic degradation (such as *Albizia guachapele, Cordia alliodora, Gliricidia sepium,* and *Leucaena* spp.). The immediate development needs of the host country, by contrast, may be better satisfied by concentrating on the testing and breeding of high-performing plantation species such as *Gmelina arborea, Tectona grandis* and *Eucalyptus* spp. These species can make a valuable contribution to the wood supply situation and the development of the forest industry in developing countries. Thus there may be some coincidence between conservation and development priorities here, as the establishment of plantations of high-performing exotics may serve to alleviate pressure on native forest resources.

Forestry extension organisations are commonly interested both in high-performing plantation species and in multi-purpose trees. The emphasis that has commonly been placed by such organisations on plantation-type exotics, due to their impressive growth rates, may not always reflect the needs of small farmers. These might better be served by native multi-purpose species, whose characteristics and products are familiar and for which seed is easily available locally without the need for outside assistance. These species may in fact include many of the same ones which are of interest to genetic conservation programmes. Genetic conservation programmes can be of benefit to extension organisations by demonstrating to them the potential of native species and by supplying seed where necessary.

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[1] A.J. Simons, ICRAF, Nairobi

The use of exotic species, particularly in smallholder situations, may not always be in the best interests of genetic conservation. Hellin and Hughes (1993) suggest that the promotion of exotic species may lead to the neglect by local people of sustainable traditional management systems involving indigenous trees. Such systems are instrumental in perpetuating populations *in situ* in environments of intensive agricultural activity. There is, in addition, a risk of weediness associated with the use of introduced species in smallholder forestry programmes: they may physically overrun and replace natural species and habitats, or they may hybridise with closely-related native species, leading ultimately to the depletion of the pure native species at the expense of the hybrid (Hughes 1994).

POPULATION MANAGEMENT

The Multiple Population Breeding Strategy (Namkoong *et al.* 1980) allows individual populations to be bred separately for specific end-uses. The proposed beneficiaries must have clear and specific requirements for certain sets of tree characteristics, which can then be enhanced by breeding and selection. They must also be able to maintain the integrity of populations following release, by avoiding their crossing with other populations of the same species. This strategy is therefore most appropriate for supplying industrial style plantations.

Small farmers, however, are normally unable to maintain the integrity of populations following release; they also require trees for a wide range of different end-uses. There are two alternative approaches to satisfying their diverse needs while avoiding the problem of genetic gain being diluted in future generations: supplying separate populations for each end-use, which are unable to hybridise either with each other or with populations already present in the area; or supplying a single population of a multi-purpose species which is diverse enough to be able to supply all of the end-uses. The first approach would greatly limit the range of potential species which could be used, by excluding native or naturalised species. The second approach approximates to the way farmers normally utilise species such as *Leucaena salvadorensis*: some trees are used for houseposts due to their straightness, for example, and others are used for firewood as they resprout rapidly.

POPULATION CHOICE

The population selected as the focus for breeding work depends upon the breeding strategy chosen which in turn, as explained above, depends on the nature of the end-user. To supply plantation managers using, for example, the Multiple Population Breeding Strategy, wild populations should be chosen which show some of the required characteristics. These characteristics should then be accentuated by breeding and selection. Simons and Dunsdon (1992) show the existence of such inter-population variation which may be exploited in this way within *G. sepium.* By contrast, if the aim is to supply diverse material for smallholder use, the best population to use might be a diverse one which demonstrates good overall growth rate, rather than any particular morphological characteristic.

In order to conserve population diversity, it is preferable that priority be given to the use of local provenances, in programmes involved in planting native species. This is also likely to be the most practical option for local people as they can be collected locally at little or no cost. A conflict between conservation interests and local people's needs may arise, however, if there is a demand for improved growth rates or for the accentuation of specific morphological traits, and if these are offered by exotic provenances. In such a situation the tree breeder may be faced with the dilemma of whether actively to promote such provenances in the knowledge that they may have negative effects on population conservation; or to underemphasise them or even restrict their introduction into the area concerned. This decision is in fact normally taken out of the tree breeder's hands, as the status of many tree breeding and conservation projects within bilateral aid programmes makes the satisfaction of local needs a political priority; and anyway restrictions on the informal movement of seed would in most cases be impossible to enforce.

LOCATION OF *EX SITU* ACTIVITIES

The establishment of centralised experimental stations (such as the La Soledad and Santa Rosa sites managed by CONSEFORH in Honduras), within which *ex situ* conservation and seed supply plantations are concentrated, provides the opportunity for the development of resource centres for research and demonstration activities. This can provide benefits for other organisations, for farmers and for the public as a whole, and thereby increase the acceptability of the genetic conservation programme within the host country and help to offset some of the negative aspects of conservation. Such centralised sites are also relatively easy to protect and manage, at least in the short term. Agricultural pressure and land shortages may, however, make the location of suitable sites and the securing of long-term tenure difficult.

On-farm plantings, by contrast, may provide individual farmers with more direct benefits, which may be provided for under management agreements. They are also more accessible for casual visits by the rural population, although they may lack the demonstration facilities available in more centralised sites. On-farm plantings are an alternative if medium-scale farmers are available who are willing to participate in management agreements, and who have security of land tenure and sufficient land to spare from agricultural activities. Most of the genetic conservation and seed production plantations of the ODA-supported Forest Genetic Improvement Project (MGF) at CATIE in Costa Rica have been established on-farm.

CONCLUSIONS

The dry forest zone of Central America clearly presents challenges which cannot be met by reliance on conventional top-down approaches to conservation and tree improvement. Small farmers should be recognised as the key to sustainable conservation: they are the best-placed, if given adequate support, to protect forest remnants and to regenerate degraded populations. It appears that their needs, and the needs of genetic conservation are in fact to a large extent compatible: both would benefit from the planting of genetically diverse populations which include useful indigenous species. Seed supply programmes should be 'demand-led', according to a clear understanding of the needs of small farmers and of their traditional methods of managing germplasm, rather than the preconceptions of the tree breeder.

There are, however, areas in which the needs of genetic conservation and of small farmers are incompatible. There is also potential for conflict between the needs of local smallholders, the region's national Governments, and smallholders world-wide. These conflicts are largely taken out of the hands of the tree breeder and the conservationist by practical and political considerations: even were it desirable, it would be next to impossible to enforce conservation against the wishes of the people. It would also be difficult to pursue a course of action that was in direct conflict with the policies of host Governments, upon whose goodwill conservation and seed supply programmes depend heavily. Where the tree breeder or the conservationist is faced with having to prioritise the needs of different beneficiaries, the decision taken must ultimately depend on the philosophy of the particular agency concerned, rather than on technical considerations.

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Trees and farming in the dry zone of southern Honduras I: *campesino* tree husbandry practices.

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Abstract

Forest cover in the dry zone of southern Honduras has suffered drastic reduction, largely as a result of the marginalisation of small farmers onto formerly wooded hillsides. In four case study communities, the relations between the area's human population and the remaining tree diversity were investigated through a combination of interviews, focus group meetings and inventories. Inventories on 10 farms in 2 communities found an average of 57.6 standing trees (above 2 m in height) and 9388.3 live stumps and seedlings of tree and shrub species (less than 2 m in height) per hectare in recently cropped fields. Tree management practices were found to include the selective promotion of naturally regenerated trees valued by farmers for their products, the elimination of unwanted trees due to competition with crops for light and space, and pruning to reduce competition. Farmers listed 41 species as being actively protected, although protection was largely concentrated on a subset of 5 (*Cordia alliodora, Swietenia humilis, Lysiloma* spp., *Enterolobium cyclocarpum* and *Albizia saman*, in that order); they also described broadening their species preferences in the face of scarcity of preferred species. The study questions the common perception of dry zone farmers as being responsible for continued elimination of tree diversity, and highlights the potential of the management of natural regeneration for meeting the livelihood needs of small farmers.

Introduction

This paper examines the relationships between the rural human population of the dry forest zone of southern Honduras and the area's remaining tree diversity. The research on which it is based was carried out between 1998 and 2000, within the context of concern about the future of Tropical Dry Forest. This has been characterised by Janzen (1988) as "the most endangered major tropical ecosystem", with only 2% of its original extent across Mesoamerica in a state "sufficiently intact to attract the attention of the traditional conservationist". The conservation status of Mesoamerican dry forest varies widely across the region. Extensive areas of apparently intact forest (much of which is probably in reality very old re-growth following pre-Columbian clearance for shifting agriculture) still remain in Mexican Pacific states such as Oaxaca, Guerrero and Jalisco. In Guanacaste, Costa Rica, large areas previously degraded by cattle ranching are currently in a process of recovery (in some cases assisted; Janzen 1986). On the Pacific slopes and coastal plains of Nicaragua, Honduras, El Salvador and Guatemala almost all of the original forest cover has gone; most of the small

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patches which do exist are relatively young re-growth (Boshier et al. in press; Gordon et al. 2003).

The dry forest zone of southern Honduras extends from sea level to around 800m.a.s.l. and consists of two clearly distinguishable zones: the extensive flat coastal plains and the heavily dissected hilly areas inland. The coastal plains are dominated by a combination of commercial agriculture (principally sugar cane and melons) and degraded cattle pasture. By contrast, the dissected hilly areas inland are dominated by thousands of small-scale (*minifundista*) farmers producing staple grains. The hill areas are particularly impoverished, with 50% of agricultural holdings below 2 ha in size (DGECH 1993) and very high population growth rates, which have resulted in population densities increasing more than three-fold over the second half of the 20th century (Stonich 1993). The population is largely *mestizo* (mixed indigenous/ Spanish) and there is little evidence of the customs and traditional attachment to the land and other natural resources that still survive in some areas of Honduras with greater indigenous presence, such as the western departments of Intibucá and Lempira.

In a companion paper, Gordon et al. (this volume) present the results of parallel botanical surveys, which indicate that the southern Honduran landscape has very few species considered a global priority for biodiversity conservation. This highly altered ecosystem is, however, home to a number of very useful, versatile and resistant tree species which are of great importance to the livelihoods of local farmers and their families. Opportunities for the realisation of the full potential of these species depend to a large extent on the continued existence of diverse and thriving populations within their natural range. This paper examines farmers' interactions with this valuable resource.

Research methods

The area covered by the study consisted of the dry forest zone of the Departments of Choluteca and Valle, in southern Honduras. Within this area, four small rural communities (ranging in size from 57 to 160 houses) were selected as case studies, such that, between them, they approximately represented the diversity of physical, socio-economic and vegetation conditions commonly found in rural communities in southern Honduras. The criteria used for community selection (see Table 1) were the following:

Table 1. Selection criteria of the study communities in southern Honduras

Variable	San Juan Arriba	Agua Zarca	San José de las Conchas	Los Coyotes
Municipality (Department)	El Corpus (Choluteca)	Langue (Valle)	Marcovia (Choluteca)	El Triunfo (Choluteca)
Geographical location and altitude	Hilly area near the Nicaraguan border, at 500 m.a.s.l.	Foothills near the El Salvador border, at 100-150 m.a.s.l.	Coastal plains and hill outliers, at 0-150 m.a.s.l	Foothills near the Nicaraguan border, at 50-150 m.a.s.l.
Annual rainfall	2,200 mm	1,800 mm (very pronounced dry season)	1,800 mm (pronounced dry season)	2,200 mm
Distinctive crops	Shade coffee and fruit	*Maicillo*, pigs, *Simarouba glauca* soap	Cattle, fishing	Timber and firewood
Access to markets	Moderate (dominated by intermediaries)	Poor (limited road access)	Moderate	Good (near to major town)
Importance of cash crops	High (coffee and fruit)	Low (due to limited road access)	Moderate (principally cattle)	Moderate (much timber and fuel-wood sale)
Access to off-farm employment	Excellent (contractors provide transport)	Poor (due to limited road access and isolation)	Moderate	Moderate
Institutional and project activity	High (easily accessible and of importance for water production)	Negligible (on a badly maintained no through road)	Limited (not obviously very poor or important for water production)	Moderate (a food-for-work forestry project in the 1990s)

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

– Altitude, topography and geographical location (ranging from 0 to 600 m.a.s.l., including inland hilly areas, coastal plains and hill outliers in the coastal plains, and extending from near the border with Nicaragua in the extreme east to near the border with El Salvador in the extreme west);
– Rainfall (with annual totals ranging from 1,800 to 2,200mm and, more significantly, varyingly severe dry seasons, one indicator of which is whether or not the drought resistant *maicillo* (*Sorghum bicolor* L.) is cultivated);
– Access to income sources from cash crop sale and off-farm employment (ranging from communities with good road access to major towns, to isolated communities depending on staple grain production)
– Crop types (including communities with and without shade coffee and *maicillo*, and with cattle and fruit production of varying degrees of importance)
– Institutional activity (including communities located on and off the "routes" of NGOs, projects and institutions, and intermediate cases).

In Honduras, dry forest also occurs in interior valleys affected by rain shadow effects, such as the Jesús de Otoro, Comayagua and Aguán valleys. The results of the research presented here are not necessarily applicable to such areas, whose social and biological conditions are in many cases different from those of the southern dry zone.

The selection of the families to be interviewed began with a participatory stratification process, in which participants defined stratification criteria and categorised the members of their communities accordingly. The criteria most often used by the participants to describe economic status were size of land holding and number of cattle; these criteria, and the numerical limits of each class, varied between communities, according to the participants' definitions. Within the framework of this stratification, a total of 79 families were selected randomly, spread approximately equally among the four communities. Overall sampling intensity was 18% of households (intensities varied between the study communities from 12.5 to 33.2%); 35% of those interviewed were women.

Between January and September 1998, semi-structured interviews were carried out in the homes of each of the 79 families. The interviews involved the initial collection of quantitative data (for example holding size, areas under different crops, and cropping periods) followed by open discussions loosely structured around the themes of agricultural production systems, the roles and uses of trees, and the interviewees' perceptions of trees in different situations within the farm. The flexible and conversational nature of these interviews gave opportunities for exploring particularly interesting or unforeseen themes as they emerged. Where farmers' time permitted, land units at varying distances from the house were visited as an extension of the interviews, permitting the researchers to witness and discuss with the farmers the different stages and processes of the agricultural cycle, including fallow clearance, sowing, weeding, harvest and post-harvest grazing.

Written notes were taken of farmers' comments during the interviews. From these, an *ex post* categorisation was carried out of the topics and species listed and observations made, and the numbers of interviews in which different observations were made were quantified.

To discuss specific themes in more depth, seven focus group meetings were also held; in each, between five and eight people participated, selected as being reliable informants from those originally interviewed. Tools borrowed from Participatory Rural Appraisal were applied to stimulate discussion and clarify points: flow charts using cards were used to characterise the agricultural cycle, and matrices with point systems were used to determine preferences for different tree species and the relative priorities of different crops and income sources for community members. Meetings were taped and subsequently transcribed. At the end of the research period, feedback meetings were held in each community to present and discuss results.

Inventories of tree germplasm were carried out in April 2000 (near the end of the dry season) in the fields of ten farmers in the two study communities of Agua Zarca and Los Coyotes. These two communities were chosen purposively out of the four studied as representing the most extreme cases out of the four studied in terms of market access (bad and good access respectively). Given the small sample size of farmers, the farmers selected were also chosen purposively from those included in the earlier socioeconomic research, spaced approximately evenly across the gradient of land holding size. With each farmer, the field most recently used was studied: all live trees (including stumps and seedlings) were counted and identified to species level in six systematically located 0.01ha circular plots in each field. In addition, the total number of standing trees (more than 2 m in height) of different species was counted in the whole field.

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

Table 2. Distribution of different land uses on farms of interviewed farmers in southern Honduras

Land Use	San Juan Arriba		Agua Zarca		San José de las Conchas		Los Coyotes	
	Average area							
	ha	% of farm	ha	% of farm	ha	% of farm	ha	% of farm
Solar (home garden)	0.9	3.6	0.8	8.5	0.6	5.5	0.8	11.9
Coffee	8.0	32.4	0.0	0.0	0.0	0.0	0.0	0.0
Staple grains	2.6	10.5	2.4	25.1	2.1	19.3	3.4	50.7
Bananas	0.2	0.8	0.1	1.1	0.0	0.0	0.1	1.5
Sugar cane	1.1	4.5	0.0	0.0	0.0	0.0	0.1	1.5
Fruit trees	0.3	1.2	0.8	8.5	0.0	0.0	0.4	6.0
Pasture	4.2	17.0	0.3	3.2	1.7	15.6	1.0	14.9
Woodlots	7.2	29.1	1.7	18.1	6.5	59.6	1.0	14.9
Other crops	0.2	0.8	3.4	36.2	0.0	0.0	0.0	0.0
Total	24.7	100.0	9.4	100.0	10.9	100.0	6.7	100.0

The area of each field was estimated by taking range-finder measurements from a central point to eight points of the compass.

Results

Cropping systems

Smallholder farms in the study area were found to contain a wide diversity of land use categories (Table 2). These include "*milpas*" dedicated to annual cropping (principally staple grains including maize *Zea mays* L., "*maicillo*" *S. bicolor* L. and beans *Phaseolus vulgaris* L.); pastures sown with the exotic *jaraguá* grass (*Hyparrhenia rufa* (Nees) Stapf); home gardens (*solares*); small woodlots and, in some higher, moister areas, coffee plantations (see Table 2). Farm units are managed on a cyclical basis, alternating between periods of food crop production, cattle grazing and fallow. The duration of each of these periods varies widely, depending largely on land availability, fertility and the presence or otherwise of cattle; the average lengths of cropping and fallow periods reported by the interviewees were 2 and 5.6 years respectively; fallow periods ranged from 1 to 20 years, more than 50% being shorter than 4 years. Fallow vegetation on steep land is cleared manually for sowing and fire is commonly used to clear thorny areas. Crop seeds are sown with a dibble stick or (in the case of *maicillo*) broadcast. In the dry season, cattle are put into fields to eat crop residues until such time as these become exhausted and the field becomes overgrown with naturally regenerated trees and shrubs. Distinctions between *milpas*, pastures, fallows and woodlots are blurred; Gordon et al. (this volume), in a companion article, report very similar assortments of tree species in these different land use types. Only one example was found of active management of fallows, that of a particularly innovative farmer who broadcast seed of laurel (*Cordia alliodora* (Ruíz and Pavón)) in a fallow.

Trees in fields

Farmers listed 41 different species of trees which, when fallow areas are cleared for cultivation, are left unfelled and protected from fire (if this is used) because of their potential future value. A subset of 5 species was listed as most frequently used, these being (in order of frequency of mention) *C. alliodora,* little-leafed mahogany or caoba (*Swietenia humilis* Zucc.), quebracho (*Lysiloma* spp.), guanacaste negro (*Enterolobium cyclocarpum* (Jacq.) Griseb.) and carreto negro (*Albizia saman* (Jacq.) Merrill). Inventories carried out on ten farms in two study communities found an average of 57.6 standing trees (above 2 m in height) per hectare of *milpa*, though densities vary widely between farms (Table 3). All of the trees found in the inventories were the product of natural regeneration.

Farmers explained that they perceive a number of negative interactions between trees and crops, which limit the numbers of trees which they are willing to leave standing in their fields. These perceived phenomena include the reduction of crop yields by tree shade; damage to crops from raindrops falling from trees' leaves; young crop plants being crushed

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

Table 3. Tree densities in maize fields in two communities in the dry zone of southern Honduras (late dry season 2000)

	Agua Zarca (n=6 farms)		Los Coyotes (n=4 farms)		
	Range	Average	Range	Average	Overall average
Trees (> 2 m) ha^{-1}	13 – 139	43.0	27 – 102	75.6	57.6
Stumps (< 2 m) ha^{-1}	2917 – 7550	5636.1	3983 – 8500	6495.8	5980.0
Seedlings (< 2 m) ha^{-1}	1567 – 10167	4627.8	1367 – 1650	1545.8	3395.0
Stumps+seedlings ha^{-1}	6567 – 17717	10286.1	5633 – 10067	8041.7	9388.3

by the leaves of large-leaved tree species such as chaparro (*Curatella americana* L.); space for crops being occupied by low-spreading species such as *C. americana*; the yellowing of maize plants hit by exudate falling from madreado trees (*Gliricidia sepium* (Jacq.) Walp.); and crop growth being affected by tree species considered as being 'hot'. This 'hot' phenomenon is described for *C. alliodora*, carbón negro (*Mimosa tenuiflora* (Willd.) Poir.), and for the fallen leaves of mango (*Mangifera indica* L.) and aceituno (*Simarouba glauca* DC); some farmers relate it, at least in the case of *C. alliodora*, to nutrient competition and say that its severity increases with tree density.

Positive effects of trees on soil humidity or fertility, or other benefits for land husbandry, were very seldom described by farmers or given as motivations for tree retention in fields. Exceptions included descriptions of the improvement of maize yields as a result of the falling leaves of carreto negro (*Albizia saman* (Jacq.) Merrill) and guanacaste blanco (*Albizia niopoides* (Bentham) Burkart); the conservation of moisture in the late season (*postrera*) sowing of maize (leading farmers to retain even *C. americana*, otherwise considered as a harmful species as described above); and the "heat" provided by *M. tenuiflora* which is considered beneficial to maize in cool periods. Farmers also reported sparing trees when they clear fallows, in order for them to provide shade for cattle when these are subsequently introduced into the *milpa* to eat crop residues.

Other strategies described by farmers for limiting tree/crop competition, and observed in the course of the study, include the restriction of trees to field edges, where crops are not established due to the risk of browsing by animals from outside the field; and the use of pruning. In order to avoid unduly affecting tree development, pruning tends to be restricted to the lower branches (up to 3-4 m above ground level); however some instances were found of farmers climbing trees to prune them for up to ¾ of their height. Female trees of *S. glauca* are largely exempt from pruning in areas where the seeds of this species are used for soap production, in order not to reduce seed yields. An additional reason given for pruning is that it promotes the straight growth of trees destined for timber; however, it was observed that branches are typically cut at a distance of several inches from the stem, leaving protruding pegs and thereby reducing the quality of the timber by contributing to the formation of dry knots. No indication was given by farmers that the timing of pruning was related to tree phenology.

In addition to trees deliberately left standing, the inventories revealed high densities of inconspicuous live stumps and seedlings (up to 17,717 per hectare) in farmers' fields (Table 3). The composition of these is very strongly dominated by species not reported by farmers as being of direct value, such as *Casearia corymbosa* HBK and *Stemmadenia obovata* (Hook. and Arn.) Schum. These species' survival in this highly modified environment, despite repeated cutting and burning, is a reflection of their tenacious pioneer character.

The retention and protection of trees in fields was described by farmers across the whole spectrum of socio-economic well-being and land-holding size. Even those who cultivate on rented land described how they respect valuable trees during land clearing, even though they may have no rights to use them (these rights depend on individually negotiated agreements between the renter and the landowner). Such protection is often imposed by landowners as a condition of rental, while others hesitate to rent out land for fear of damage to their trees.

Trees in pastures

As in cropping areas, farmers perceived trees in pastures as having both positive and negative effects on productivity (in this case of pasture grasses and livestock). Although the shade which they provide is val-

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

ued for cattle, it is also perceived to suppress the development of the most commonly-used pasture grass, *H. rufa*. Shade is regulated either by felling trees, or by pruning or pollarding them to 3-4 m height. Livestock owners rarely referred to trees in pastures as being valued for the fodder provided by their leaves; greater store as fodder was given to the fruit of trees such as *A. saman*, *E. cyclocarpum*, guácimo negro (*Guazuma ulmifolia* Lam.), jícaro (*Crescentia alata* HBK) and nacascolo (*Caesalpinia coriaria* (Jacq.) Willd.). Jícaro fruit are sometimes collected from on-farm trees and carried to the livestock as feed.

Trees in solares

The term *solar* normally refers to the area immediately around the house. *Solares* tend to be relatively constant in size (around 0.6 − 0.9 ha) between farms and between communities (Table 2). They tend to be dominated by planted, rather than naturally regenerated trees, which can easily be protected and watered due to their closeness to the house; this situation contrasts with that in fields, where, as described above, most trees are naturally regenerated and any planted trees would be vulnerable to damage by cattle introduced to graze crop residues. Trees in *solares* are largely allowed to develop freely, in order to provide fruit and shade for the house; in general, fruit production was the most common reason given by interviewees for having planted trees (almost twice as many farmers described having planted trees for fruit as for timber).

Despite their relatively constant size, *solares* do vary in nature between communities and this affects the ways in which the trees which they contain are managed. In some, they are taken to include an area of secondary forest near the house, which is kept as a reserve of tree products. Sometimes they include a small area of staple grain cultivation, and here the perceptions and management of trees are similar to those found in the main cropping areas elsewhere in the farm. In communities in which the raising of cattle is important, many are used as night corrals for cattle, a practice which can seriously limit opportunities for tree growing, or require that planted trees are elaborately protected against browsing.

Farmers prefer to maintain a diverse range of fruit trees in the *solar* to ensure year-round availability of fruit. In a focus group meeting in San Juan Arriba, for example, farmers listed 29 different fruit species, of which at least five are in production in any given month. *Solares* are the only part of the farm where exotics (e.g., *Citrus* spp., *M. indica* and tamarind (*Tamarindus indica* L.)) are dominant, though they also contain many native or naturalised species (e.g., guava (*Psidium guajava* L.) and jocote (*Spondias purpurea* L.)). They are also used as a trial site for new tree species, of whose value or use farmers may be uncertain, such as the exotic *Azadirachta indica* (A. Juss.), which has been heavily promoted by development NGOs and projects.

Trees in woodlands

Many farms (30.4% of those interviewed), across the spectrum of land-holding sizes, contain areas of woodland (termed "*bosque*" or "*montaña*"), which result from farmers allowing parts of their farms to lie fallow for longer than the normal crop/fallow rotation cycle would require (the average duration is 2 and 5.6 years for cropping and fallow periods respectively). These areas are commonly located on the steeper and more inaccessible parts of the farm and are used as a reserve of timber, posts and other forest products. The majority of the small woodlots in the south of Honduras probably owe their existence to this practice (Gordon et al. this volume). These reserves are not necessarily permanent features; it is not uncommon after several decades for the farmer to clear the reserve and use the land for cultivation, leaving another area of the farm as a long-term fallow in its place. The shortage of labour was given as a reason, by some older farmers whose sons no longer work the land with them, for these reserves assuming an increased economic importance, as a source of timber and posts for sale, relative to more labour-demanding agricultural activities.

Trees in coffee plantations

In San Juan Arriba, the one study community where coffee is cultivated (by 45% of those interviewed), farmer interviews and studies of aerial photographs indicated that this crop is losing importance, due to a combination of marginally suitable climatic and altitudinal conditions, and recent slumps in coffee prices. Most of the plantations are of the 'traditional polyculture' type (Moguel and Toledo 1999), with low intensity management and a shade canopy derived from native forest. Even some of the smallest landowners have areas of coffee, as small as 0.1ha, which serve

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

for domestic consumption and receive almost no management. Some larger, more intensively-managed plantations (up to 70-80ha in area) come closer to the 'commercial polyculture' type (*ibid*.), with a progressive replacement of natural trees with planted *Inga* spp.

The fact that trees such as *C. alliodora* and *Hymenaea courbaril* L., which were ranked highly by farmers for timber quality but low for coffee shade characteristics, are commonly found in traditional polyculture plantations, implies that farmers manage such areas with multiple objectives in mind (although only the largest landowners interviewed named coffee plantations as one of their principal sources of timber). Coffee plantations are also important sources of fuelwood, for community members across the gradient of economic wellbeing classes; those without land collect it either with or without the permission of the owners, and in any case normally without payment.

Tree management in the coffee plantations consists principally of pruning and in some cases thinning, to regulate shade. Natural regeneration is allowed to develop with little interference. When over-mature trees fall, the resulting gap is filled by temporary shade such as banana plants (*Musa* spp.), which is eventually replaced by trees (especially *Inga* spp.) planted as permanent shade.

Trends in patterns of forest cover

The considerable size of pre-conquest indigenous populations in the lowlands of southern Honduras deduced by Newson (1992) and Stonich (1993) makes it likely that forest alteration and clearance, through agricultural and extractive activities, was significant in scale in pre-Colombian times (Denevan 1992). Trends in forest cover prior to the 20th century are otherwise hard to detect due to the paucity of reliable historical and inventory data. Comparison of aerial photographs from 1954 and the early 1980s, backed up by the interviews and focus group meetings described above, indicate that during the 20th century a drastic loss of remaining forest and fallow areas occurred. The aerial photographs clearly show that a number of contrasting processes have taken place in different parts of the region over the last half century, including the following:

– Significant areas of forest on the coastal lowlands have been converted to commercial melon and sugarcane estates.
– Vegetation on some hill outliers in the coastal plains area has recovered from degradation caused by earlier extensive cattle grazing.
– Large areas of coffee plantations under semi-natural shade, in the higher, more humid areas near the Nicaraguan border, have been cleared for smallholder staple grain production.
– In some foothill areas (for example around Los Coyotes), an earlier situation of temporary scattered maize and bean fields within a matrix of variable-aged fallow and forest has changed to one dominated by fields with permanent boundaries and little remaining forest cover.
– A state of relatively stable flux has been maintained in the mosaic of agricultural fields and fallows in other foothill areas, for example near the border with El Salvador.

Trends in species preferences

Farmers who participated in a focus group meeting in the case study community of Los Coyotes indicated, through a time-line exercise, that in response to increasing scarcity of preferred tree species as a result of over-exploitation, they have broadened the criteria which they use for the selection of tree products; consequently, they now use a greater diversity of species, considered as being of lower quality, than previously. The exercise showed that they have changed from using, for commercial timber, exclusively *Bombacopsis quinata* (Jacq.) Dugand, which is now severely depleted, to a set of eight different, less-favoured but more easily available species (*Albizia adinocephala* (Britt. and Rose) Donnell-Smithii, *A. saman, Cedrela odorata* L., *C. alliodora, E. cyclocarpum, G. ulmifolia., S. glauca,* and *S. humilis*.). Through necessity, this change is tolerated by local timber markets despite a continued preference for a few more valued species. They also reported that other species previously used for firewood are now reserved for timber, due to shortages of timber.

Discussion

A number of factors have contributed to the overall reduction in the area of forest and fallows in the dry forest zone of southern Honduras:

– Land tenure inequities (with deep social and cultural roots) and economic and political pressures

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

for the promotion of large scale commercial agriculture, which have led to the marginalisation and translocation of small farmers onto the hilly areas inland;
– High subsequent population growth rates in the hilly areas, which have led to increases in the overall area of land in cultivation and consequently a reduction in the area left as fallow and the duration of fallow periods;
– Land reform programmes from the 1960s on, which have promoted the clearance of lowland forest in order for the land to fulfil its 'social function' (these programmes moved many steep land farmers back onto the lowlands, but a lack of technical and organizational support resulted in many leasing or selling the land to commercial agricultural interests).

This study shows that farmers consider and manage trees in very different ways in each of the different land units that make up the typical farm. The most significant of the on-farm tree husbandry practices described here, both in terms of the area which it covers, and its potential as a vehicle for sustainable ecosystem management, is the management of natural regeneration in fields. Tree management in *solares*, by contrast, is based largely on the planting of exotic trees and is limited in area coverage; while coffee plantations, although dominated by naturally regenerated trees, are limited in extent and in decline in the study zone. Tree management in fields is a combination of several phenomena:

1. Non-intentional modification of natural selection pressures by incidental disturbance in the course of agricultural operations, such as burning and grazing;
2. Intentional selective promotion of desired trees (normally by protection);
3. Intentional elimination of many unwanted trees;
4. Silvicultural manipulation of those trees which are actively protected, to reduce tree/crop competition through the pruning of lateral branches and improve timber quality (though often with limited effectiveness) through the elimination of forks;
5. Passive tolerance of those trees which the farmer is unable to eliminate.

Farmers' interactions with trees, as observed in the study communities and reported by the farmers themselves, combine positive and negative selection. On the one hand, they impose negative selection pressures by preferentially harvesting and using the best-formed individuals of preferred species, thereby removing them from breeding populations. However (in contrast to selective extraction from unmanaged natural forests), they also apply positive selection pressures, by eliminating poorly formed individuals or non-useful species, which occupy valuable space, from tree populations as they develop in their fields.

Actively protected trees in fields in fact only make up a very small proportion of the total number of individuals of tree and shrub species, if inconspicuous live stumps and seedlings are taken into account as well (Table 3). Factors which contribute to the survival of the bulk of this prolific germplasm include its tenacious nature and the low impact nature of the agricultural systems applied on steep lands, which are principally limited to the aerial parts of the vegetation and leave regenerative material within the soil (stumps and seeds) virtually untouched.

Due to the complexity of the situation which it sought to describe, the research described here depended largely on farmers' explanations of their activities and motivations, rather than (with the exception of the inventory of on-farm germplasm) quantitative field measurements. It provided a detailed descriptive understanding of the relations between farmers and trees in the study area, and also served to generate a number of hypotheses which warrant further testing through more specific, quantitative research:

i) Resource scarcity as a motivation for tree husbandry

The testimonies of the farmers interviewed in this study imply that the husbandry of scattered trees in fields represents a relatively recent strategy to ensure a continued supply of tree products, in response to increasing scarcity of forest and fallow resources. The resolution of the aerial photographs studied was not sufficient to detect changes in densities of scattered trees in fields, which might have been compared with census data on trends in population levels and farm sizes in order to confirm this hypothesis. However if true, this would be very much in line with the conclusions of Arnold and Dewees (1998), on the basis of case studies from Kenya, India and Nepal, that off-farm tree scarcity is a key determinant of farmers' willingness to accept increased numbers of on-farm trees.

XPS 0120332 — ms-code agfo2248 — PIPS 5144438 — 16 Sep 2003 — Grafikon 203001108

ii) Market access as a limitation on the livelihood contribution of trees

Economic research linked to the current study shows that, under conditions of good market access such as the study community of Los Coyotes, which is located near to a town which consumes large quantities of timber for furniture production, tree growing based on the protection of natural regeneration in fields can provide a very significant contribution to farm family economies (M. Richards, pers. comm., 1999). Farmers throughout the study area identified limited access to markets for tree products as a constraint to keeping more trees in their fields as a source of income; fields in Los Coyotes indeed contained around 75% more standing trees than those in the more isolated community of Agua Zarca (Table 3), however it was not possible in this study to sample a sufficiently large number of communities to determine whether such a difference could be attributed to market access rather than other factors.

iii) Legal restrictions as a disincentive for retaining trees

In addition to physical obstacles, many farmers referred to legal obstacles to market access, particularly the difficulty of obtaining permits for the felling of trees and the transportation of timber for sale, as a disincentive to retaining trees in fields as a strategy for savings and risk aversion; they compared trees unfavourably in this respect with cattle, for which ready and uncomplicated markets normally exist. These concerns reflect the centralised nature of regulations on tree use and sale, and are also in part a hangover from the situation prior to the passing of the Law for the Modernisation and Development of the Agricultural Sector in 1992, when ownership of all trees was vested in the state.

iv) Physical and economic factors as constraints on the elimination of germplasm

As shown in Table 3, large amounts of vigorous but inconspicuous live tree and shrub material survive in fields, in spite of farmers' attempts to eliminate them due to the limited utility and weedy nature of many of the species in question. Observations and interviews throughout the course of the study suggest that farmers' abilities to eliminate this unwanted material are limited by a number of physical and economic constraints:

- The steepness of the slopes onto which most small farmers are marginalised, which makes it difficult for them to de-stump and plough their fields;
- Low soil fertility relative to crop demands (many farmers lack the resources to correct this with fertilizers), which requires that land periodically be left fallow to recover fertility, allowing many species to reach reproductive age;
- Water scarcity, which limits opportunities for intensified cattle ranching which could break the fallow cycle and result in permanent pastures;
- Climate unpredictability, which limits farmers' opportunities to introduce crops other than staple grains, whose greater profitability might make it worth their while to remove competing trees and stumps;
- Labour shortages, which limit farmers' physical abilities to clear fallow land.

Conclusions

The results presented in this article run counter to the perception, commonly held at least within Central America, of dry zone farmers as the principal culprits of the apparent progressive elimination of tree diversity. Historical evidence reveals that they have, rather, been the victims of circumstances which have marginalised them onto steep hills which they have been obliged to clear for farming. The results of the inventories of trees in fields show that the dry south is far from being a treeless savannah, as perceived by many; while tree diversity has apparently been severely reduced, largely as a result of agricultural clearance and other forms of disturbance (Gordon et al. this volume), a large number of vigorous species continue to survive in the midst of farmers' activities. Farmers are revealed as active managers of the remaining tree resource; through a range of practices, they strike a careful balance between the needs and benefits of trees and of the staple grains on which they depend for survival. Their role as moulders of the tree resource should not be exaggerated, however; while they do indeed contribute to the status of the breeding populations of a number of species which are useful to them (as suggested by Hughes, 1998 in the case of *Leucaena* spp, elsewhere in Mesoamerica), the bulk of the inconspicuous live tree and shrub material present in the agroecosystem survives despite, rather than because of, their efforts.

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Development Implications

Given the low global conservation priority of most southern Honduran tree species (Gordon et al. this volume) and their contrasting importance to the livelihoods of local farm families, development activities should focus on the conservation of the tree resource principally as a resource actively to be used by local people. Rural development entities should also change their focus from promoting the planting of trees (often exotics) towards working with the vigorous natural regeneration which this study has shown to be present in the *milpas*. There is a need to explore and promote possible modifications to the current legal and institutional situation, which still presents significant disincentives to the management of on-farm trees as a saleable resource.

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Trees and farming in the dry zone of southern Honduras II: the potential for tree diversity conservation

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Abstract

The potential of the dry zone agro-ecosystem of southern Honduras to contribute to the conservation of Mesoamerican dry forest tree diversity is evaluated. Four rural communities containing eight land uses were surveyed using rapid botanical sampling resulting in the identification of 241 tree and shrub species. As a result of ordination analysis, it is concluded that the land uses are relatively similar in their species composition, particularly maize fields (*milpas)*, fallows, pastures and woodlots, because of the predominance of natural regeneration. Therefore all land uses might contribute to local tree diversity conservation. Those land uses in which planting also contributes to diversity, home gardens (*solares)* and orchards, are more distinct; however the tree species found there are widespread and often exotics and thus not the usual focus of conservation measures. Across the landscape the total complement of species considered a global priority for biodiversity conservation is very low and therefore this agro-ecosystem does not represent a good place in which to implement dry forest tree diversity conservation programmes. Instead its value is likely to be in the contribution that tree diversity makes to rural livelihoods. Particular consideration is given to *Swietenia humilis* Zucc. (small leaved mahogany) and its status as a threatened species is questioned because of its abundance within this landscape and its wide distribution.

Introduction

Increasing attention has been paid to the role that agricultural landscapes might play in the conservation of biodiversity (e.g., Halladay and Gilmour 1995; Pagiola et al. 1997; Vandemeer and Perfecto 1997). Various studies from different parts of the world have shown that certain types of traditional agricultural practices support a wide range of species and that a significant fraction of forest diversity may therefore be maintained outside of forests, (e.g., Harvey and Haber 1999; Michon et al. 1983; Steinberg 1998). However, such studies tend to consider particular land uses whereas tropical agricultural landscapes, especially those managed by resource-poor farmers, are typically composed of a mosaic of several land use types. The relationships between these land uses are a necessary consideration in the evaluation of the potential of such landscapes to contribute to conservation. Hence we carried out a tree diversity assessment in all the land uses contained within four rural communities of a Central American seasonally dry tropical agro-ecosystem.

Central American dry forest (Murphy and Lugo 1995) is the cause of considerable concern because of its almost complete conversion to agriculture (Janzen

Table 1. Location and altitude of the four case study communities in southern Honduras.

Community	Municipality	Department	altitude (m a.s.l.)
San Juan Arriba	El Corpus	Choluteca	450 − 600
Agua Zarca	Langue	Valle	250 − 350
San José de las Conchas	Marcovia	Choluteca	10 − 80
Los Coyotes	El Triunfo	Choluteca	200 − 300

1988a). Today only patches remain, with the partially restored forests of Guanacaste, Costa Rica being amongst the few suitable sites for the application of protected area conservation. Here we consider the conservation potential of the mosaic of land uses that make up the dry forest zone of southern Honduras to contribute to global tree diversity conservation by asking two questions. First, what are the species composition relationships between land uses in the mosaic? And second, are the species contained within this agro-ecosystem of conservation concern?

We assume that combating global (rather than local) species extinction is the priority. Under this assumption, the number of species present is not an adequate measure of a landscape's potential to contribute to conservation. A better measure, and the one we use here, is the number of globally threatened species present.

Study Area

The short Pacific coastline of southern Honduras, around the Gulf of Fonseca, is contained within the Departments of Choluteca and Valle between the latitudes of 13º N and14º N. The lowland coastal plains and foothills up to about 800 m a.s.l. fall within the subtropical dry forest zone as defined by Holdridge (1987). The original forests of the area have undergone almost total conversion leaving only patches of secondary forest in the foothills. Four case study communities (Table 1) from within this area were selected non-randomly to reflect a range of socio-economic gradients (Barrance et al., this volume). The communities are dominated by smallholdings in which farmers cultivate staple grains (maize and beans) for subsistence and sale, maintain small cattle herds and tend homegardens (here referred to by their local name *solares*). In more humid areas, coffee of low productivity is cultivated. There are also significant areas of fallow vegetation that are allowed to develop following the temporary abandonment of pastures and staple grain fields (here referred to by their local name *milpas*). Within this landscape, small woodlots (1 to 10 ha) derived from secondary regeneration are found. These are often, but not always, on steeper and less accessible land and are usually privately owned. The local value of tree diversity and the socio-economic dynamics that determine the management of this landscape are described in detail by Barrance et al. (this volume) and Gordon et al. (2003) who report concurrent research in the same four communities.

Methods

From within each of the four communities, twenty households were selected on a stratified random basis, stratification being according to wealth criteria defined by community members (Barrance et al., this volume). From amongst the parcels of land farmed by each household, a maximum of three were randomly selected from lists compiled during previous socio-economic research, with a maximum of one land use type surveyed per household. The exceptions to this were coffee plantations that, because they were limited to one community, were deliberately over sampled to ensure a reasonable sample size. Parcels ranged from 0.25 ha to a very few that were larger than 3 ha and each was classified into one of eight land uses by a householder, resulting in 126 parcels sampled (Table 2). Sampling followed the plotless, rapid botanical survey methodology described by Hawthorne and Abu-Juam (1995), with minor modifications. This methodology was chosen because of its speed and efficiency, compared to plot based methodologies, for broad scale assessments across a structurally diverse landscape. It sacrifices detailed information on vegetation structure for landscape level information on the correlation between species and land uses. Each sample site was delimited by the pre-existing boundaries of the parcel of land or woodlot. Each sample consisted of a species inventory derived

Table 2. Numbers of samples, by land use and by community in four communities in southern Honduras.

Community	Number of samples								
	Coffee	Fallow	Milpa	Orchard	Pasture	Solar	Wood	Unclasif	All
San Juan Arriba	7	1	3	2	2	7	7	0	29
Agua Zarca	0	9	11	4	5	8	3	0	40
San José de las Conchas	0	4	5	0	7	8	6	0	30
Los Coyotes	0	1	7	0	1	10	6	2	27
All communities	7	15	26	6	15	33	22	2	126

from 4.5 person-hours of systematic searching. Diversity conservation in this landscape would be measured in terms of numbers of parcels, rather than numbers of hectares, involved (Boshier et al. in press). Hence we do not attempt to describe the relationship between diversity and area but instead treat each parcel as a unit of land equally likely to be included in any potential conservation programme, regardless of between-parcel variation in size.

In each parcel a species was scored as present if it could be identified as a woody individual with a diameter at ground level of at least 0.5 cm, resulting in a very broad definition of woody vegetation and allowing the inclusion of live stumps. Woody climbers were not included in the analysis except species, such as those of the genus *Piper*, that can have a climbing or scandent shrub habitat. Trees and shrubs in parcel boundaries (i.e., living fences) were included within the sample. This opened the possibility for a single tree to be included in both the assessments of two adjacent sample sites. However, very few adjacent samples were taken and in none of these was a boundary tree found to be the only representative of its species in either sample.

Comparative analysis of species composition was carried out by Detrended Correspondence Analysis (DECORANA) and supplemented by Two Way Indicator Species Analysis (TWINSPAN), in both cases using the programme PCordwin™. These analytically similar ordination techniques sort vegetation samples by the degree of similarity in species composition between samples (Kent and Coker 1992). Scatter plots were derived from DECORANA presence/absence (unweighted) ordinations with each point representing a sample or group of samples and the distance between points being a representation of the degree of difference in their species composition; samples sharing most species being closest together. TWINSPAN was used to select species indicative of groups of similar samples.

Determination of each species' conservation importance was done by adaptation of the 'star system' of Hawthorne (1996). This system was used because, compared to such systems as that used by IUCN (IUCN, 2000) all identified species could be ranked with available information. Each species encountered was given a 'star ranking' based principally on its distribution estimated from collections in the National Herbarium, Mexico (MEXU) and the Paul C. Standley Herbarium, Honduras (EAP), respectively the largest collections in Mesoamerica and Honduras. Supplementary information came from monographs and from checklists from areas containing dry forest in the region (Janzen and Liesner 1980; Reyes-García and Sousa S. 1997; Lott 1993; Martin et al. 1998). It was assumed that species found to be narrowly distributed in Latin America and the Caribbean would be absent outside the region and therefore that the estimated distributions reflected global distributions. Species with narrower global distributions were ranked more highly to reflect greater conservation concern (Table 3). At the top of the scale are 'black star' species that, in this case, are endemic to the dry forest zone of Honduras. 'Gold' and 'blue star' species are of increasingly wider distribution and therefore of decreasing, but real, conservation concern. 'Green star' species are of such wide distribution that their continued existence is not considered to be currently in doubt.

The basic geographic units used here are political divisions, in which each Central American country (including Belize and Panama) is considered equal to each Mexican state. This imprecise unit of area is sufficient to allow a rapid estimation of the distribution of many species from the highly variable standard of information contained on herbarium specimen labels. This ranking system is sensitive to bias in the degree to which a species has been collected; however, the effect on an under-collected species is for it

Table 3. Criteria for assigning star rankings to tree species found in the dry forest zone of southern Honduras.

Criterion	Rank
Endemic to the Pacific dry forest zone of Honduras.	Black star
Endemic to the Mesoamerican Pacific dry forest zone and present in two to four Central American countries/Mexican states.	Gold star
Endemic to the Mesoamerican Pacific dry forest zone and present in five to eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific dry forest zone but present in one to four Central American countries/Mexican states.	Blue star
Endemic to the Mesoamerican Pacific dry forest zone and present in more than eight Central American countries/Mexican states OR ot endemic to the Mesoamerican Pacific dry forest zone but present in more than four Central American countries/Mexican states.	Green star

Table 4. Numbers of samples, woody species recorded and woody species identified by community in southern Honduras.

Community	No samples	Mean species per sample	Total species identified	No of records identified (%)
San Juan Arriba	29	30.4	162	96.1
Agua Zarca	40	32.0	152	94.6
San José de las Conchas	30	30.3	148	95.8
Los Coyotes	27	47.2	154	95.2
All communities	126	34.5	241	95.3

to be given higher rank, a desirable safeguard in the light of insufficient information.

Results

Floristics

Over 95% of records were identified to species level, resulting in a total of 241 species in 108 genera and in 23 families. Despite differences in the numbers and types of sample taken in each community, the total number of species identified for each was quite similar (Table 4). The most speciose families were Leguminosae with 52 species (Mimosaceae 23 species, Caesalpiniaceae 17 species and Papilionaceae 12 species) followed by Rubiaceae (11 species), Rutaceae (9 species) and Bignoniaceae and Sapindaceae, each with 8 species. The most speciose genera were *Citrus* and *Cordia* both with 7 species followed by *Annona*, *Mimosa* and *Senna* with 5 species. Gentry (1995), comparing samples taken from various neotropical dry forest sites, found the Leguminosae, Bignoniaceae and Rubiaceae to be, in descending order, generally the most speciose families. He found the Bignonaceae to be a family particularly rich in woody climbers, a life form included in his analysis but not in the sampling described here. This and the high species richness of Rutaceae that results from cultivation of *Citrus*, explains the major familial differences between this survey and the general conclusions of Gentry (1995). At the generic level, the dry forest florulas compared by Gentry (1995) reveal *Cordia*, *Mimosa* and *Cassia* (in which he includes *Senna*) to be consistently amongst the most speciose genera. The appearance of *Annona* and *Citrus* amongst the most speciose genera in this survey is, once again, a result of cultivation.

Figure 5 combines all the samples of each land use from each of the separate communities, thus each point represents all the species of all the samples of a given land use type from a single community. However, in the interpretation of this scatter plot it must be recalled that equal numbers of samples were not taken for each land use type in each community. This is particularly important for conclusions relating to under-sampled land uses (see Table 2).

Conservation priorities

Of the total of 241 species identified, ten emerged as conservation priorities (Table 5.) Eight of these were identified by the application of the modified star system, and two, included for discussion are listed by IUCN (2000). Of these relatively few species, the majority are of low priority (‘blue star’ or VU- vulnerable), none are endemic to southern Honduras

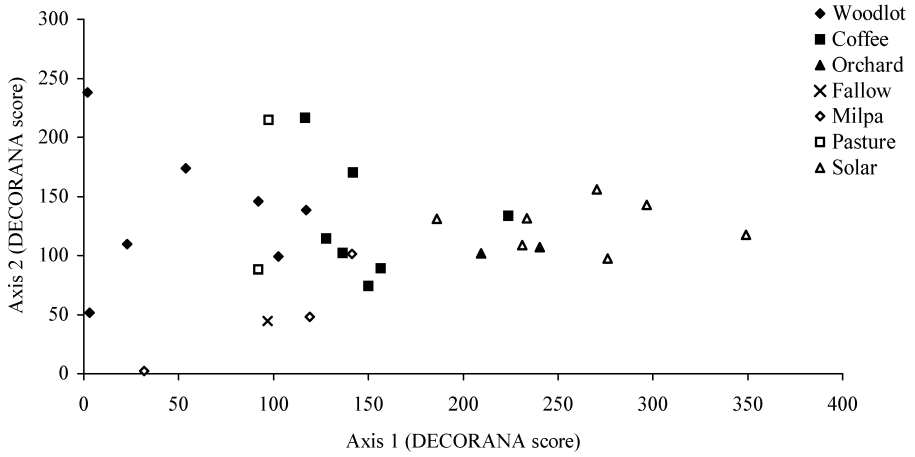

Figure 1. San Juan Arriba, southern Honduras: DECORANA ordination of species composition of all samples and all land uses.

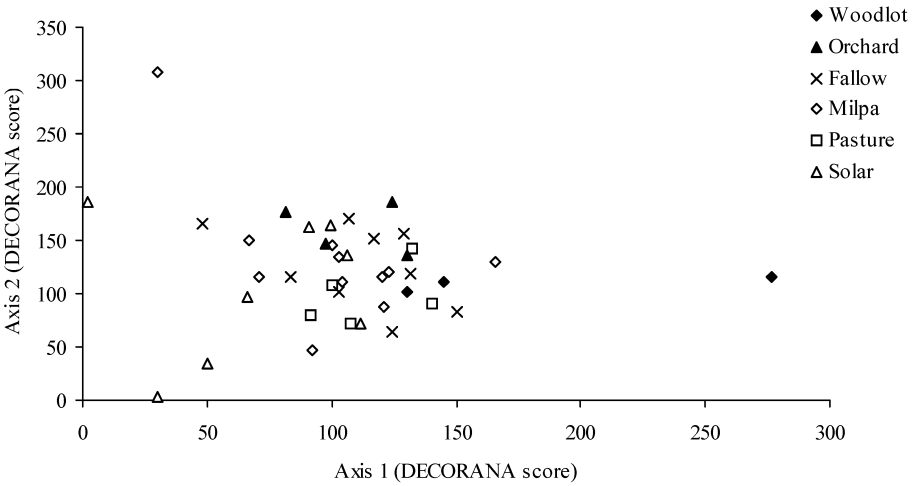

Figure 2. Agua Zarca, southern Honduras: DECORANA ordination of species composition of all samples and all land uses.

(i.e., none are 'black stars') and none are critically endangered according to IUCN (2000).

As a mean, each species (both priority and non-priority) was present in 13.7% of samples. Thus, with the exception of *Swietenia humilis* Zucc. and *Eugenia hondurensis* A. Molina, the priority species were also comparatively rare within this agro-ecosystem (Table 6). It is notable that neither of the species whose priority was set according to IUCN guidelines were also determined to be globally rare by the modified star system, although *Leucaena salvadorensis* Standl. is listed as 'lower risk-conservation dependent' by IUCN (2000). *S. humilis* is given further consideration below. Table 6 shows that no land use is without species of conservation concern. The three species which are limited to one land use are all species found only once in the entire survey, suggesting that this apparent preference may be an artefact and it would be premature to suggest that particular land uses are critical to their conservation. Amongst these species is *L. salvadorensis*, the highest priority species found (gold star). Its distribution is known to be highly patchy across its limited natural range from eastern El Salvador to north-western Nicaragua (Hughes 1998).

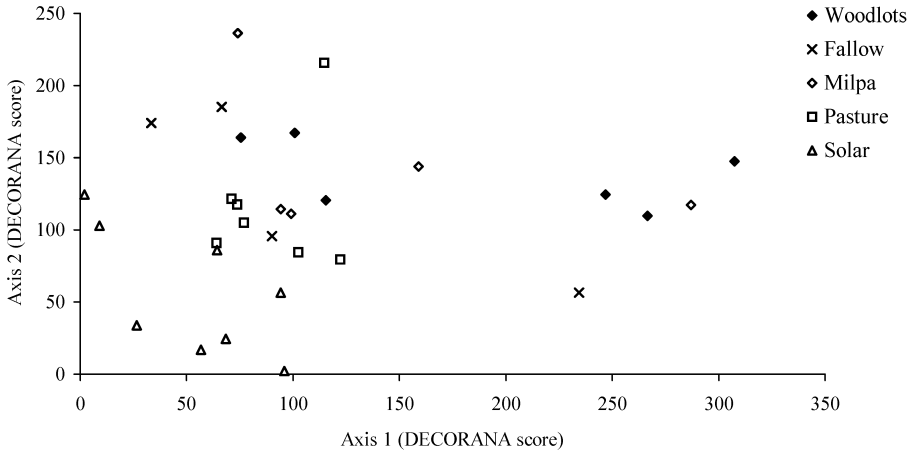

Figure 3. San José de las Conchas, southern Honduras: DECORANA ordination of species composition of all samples and all land uses.

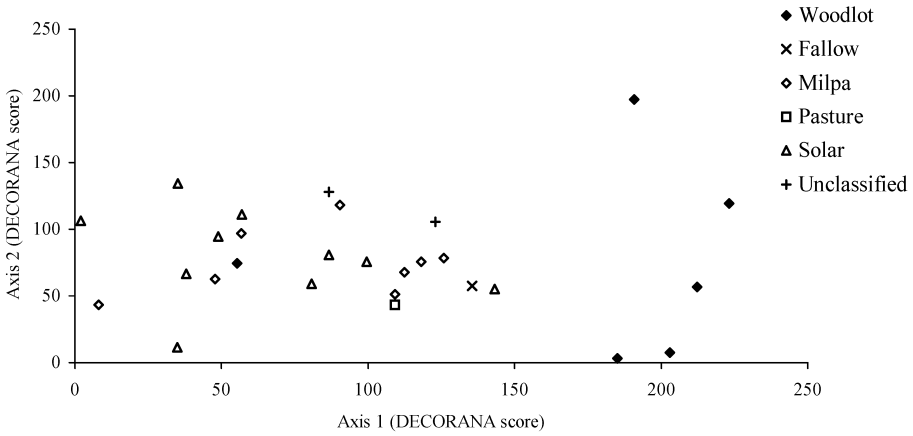

Figure 4. Los Coyotes, southern Honduras: DECORANA ordination of species composition of all samples and all land uses.

Discussion

San Juan Arriba

The ten samples furthest to the right of the San Juan Arriba scatter plot (Figure 1) contain all the *solares* and orchards sampled in the community. TWINSPAN reveals the indicators of these samples to be species that are usually planted and included five members of the genus *Citrus*, *Anacardium occidentale* L. (cashew), *Averrhoa carambola* L. (star fruit- an important cash crop only in this community), and *Annona muricata* L. (soursop). At the extreme left are concentrated the woodlots, the land use characterised by the least anthropogenic disturbance, at least over recent cropping cycles. It therefore appears that a 'regeneration gradient' exists running roughly parallel to axis 1. Samples towards the left of the axis are from land uses in which natural regeneration is predominant whilst to the right artificial regeneration, i.e., planting, is responsible for an increasing proportion of woody diversity.

In the centre of the scatter plot, samples from various land uses are intermixed, suggesting as much variation within land use types as between land use types. These are land uses in which tree and shrub diversity is largely derived from natural regeneration, but are typically subject to far greater human intervention than are woodlots. Amongst these samples are the coffee plantations, whose diversity is shown to be not notably distinct from that of the other land uses. The concentration of some of these coffee plantation samples towards the right of the putative regeneration gradient is perhaps explicable by the tendency of

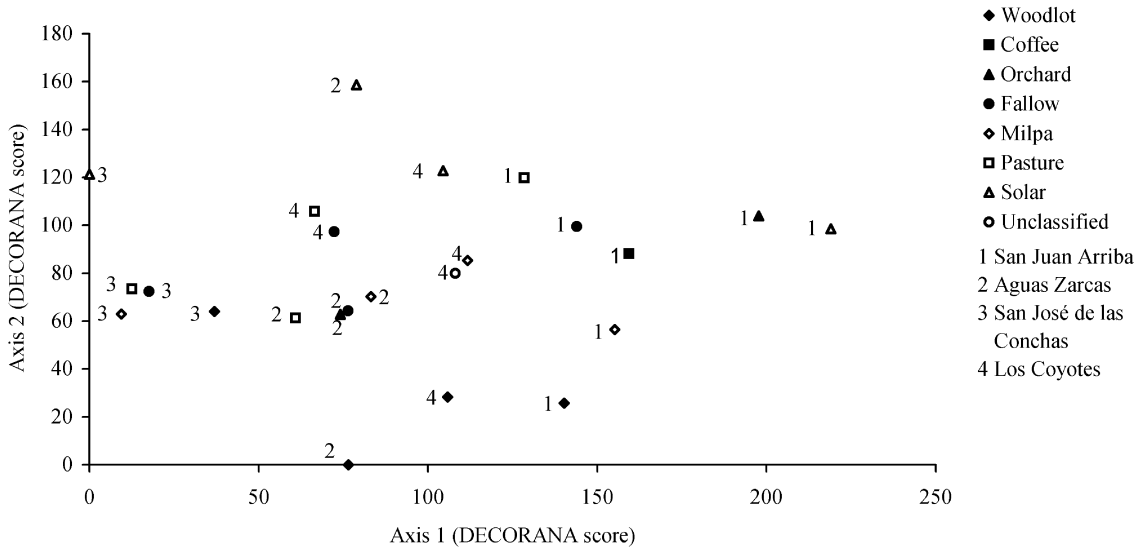

Figure 5. Aggregated samples of each land use for each of four communities in southern Honduras: DECORANA ordination of species composition.

Table 5. Priority tree species for conservation in southern Honduras as revealed by application of Hawthorne's star ranking system and IUCN listings.

Species	Star ranking	IUCN
Leucaena salvadorensis Standl. Mimosaceae	Gold star	Not listed
Actinochetia filicina (D.C.) Barkley Anacardiaceae	Blue star	Not listed
Bunchosia guatemalensis Ndzu Malpighiaceae	Blue star	Not listed
Casearia williamsiana Sleumer Flacoutiaceae	Blue star	Not listed
Eugenia hondurensis A. Molina Myrtaceae	Blue star	Not listed
Mimosa panamensis (Benth.) Standl. Mimosaceae	Blue star	Not listed
Randia pleiomeris Standl. Rubiaceae	Blue star	Not listed
Rondeletia deamii (Donn. Smith) Standl. Rubiaceae	Blue star	Not listed
Bombacopsis quinata (Jacq.) Dugand (Bombacaceae)	(Green star)	VU (IUCN)
Swietenia humilis Zucc. Meliaceae	(Green star)	VU (IUCN)

farmers to replace naturally regenerated trees, as they die or are felled, with *Inga* spp., whilst relatively little new natural regeneration is permitted below the coffee bushes.

Agua Zarca

Agua Zarca had the least differentiation between land use types with the majority of samples closely clustered in the centre of Figure 2. However, as with San Juan Arriba, there is a clear tendency for *solares* and woodlots to be grouped at opposite ends of one axis, which may again be explicable as a regeneration gradient. That the direction of this gradient is reversed with respect to Figure 1 is an artefact of DECORANA and not significant. In this community the *solar* samples are not only amongst the most distinctive but also displayed most within-land use variation; however, few (three) woodlots were encountered here and therefore this land use was relatively under-sampled. Those *solares* in the bottom left quadrant of the plot are characterised by *A. muricata*, *Bixa orelleana* L. (annatto) and *Carica papaya* L. (papaya). However, there are *solares* and fruit orchards in the centre of the scatter plot along with *milpa*, fallow, pasture and woodlot samples. This is explicable by the amount of natural regeneration that is tolerated or even encouraged in and amongst the planted species in *solares* and orchards.

Table 6. Number of samples by land use in which priority species were found, all communities combined.

Species	Number of samples in which species was found (%)							
	Coffee* N = 7	Fallow N = 15	Milpa N = 26	Orchard N= 6	Pasture N = 15	Solar N = 33	Forest N = 22	Other N = 2	All N = 126
Leucaena salvadorensis	0	0	0	0	0	1 (3.0)	0	0	1 (0.8)
Actinochetia filicina	0	2 (13.3)	5 (19.2)	0	2 (13.3)	3 (9.1)	3 (13.6)	0	15 (11.9)
Bunchosia guatemalensis	0	0	0	0	0	0	1 (4.5)	0	1 (0.8)
Casearia williamsiana	0	0	0	0	0	0	1 (4.5)	0	1 (0.8)
Eugenia hondurensis	2 (14.3)	3 (20.0)	8 (30.8)	1 (16.7)	0	5 (15.2)	5 (22.7)	1 (50.0)	25 (19.8)
Mimosa panamensis	0	2 (13.3)	2 (7.7)	0	3 (20.0)	1 (3.0)	0	0	8 (6.3)
Randia pleiomeris	0	1 (6.7)	0	0	2 (13.3)	0	0	0	3 (2.4)
Rondeletia deamii	0	0	2 (7.7)	0	0	2 (6.1)	5 (22.7)	1 (50.0)	10 (7.9)
Bombacopsis quinata	2 (14.3)	1 (6.7)	3 (11.5)	0	3 (20.0)	1 (3.0)	5 (22.7)	1 (50.0)	16 (12.7)
Swietenia humilis	0	9 (60.0)	17 (65.4)	4 (66.6)	10 (66.6)	11 (33.3)	11 (50.0)	2 (100)	64 (50.8)
Priority species combined	4	18	37	5	20	24	31	5	144
Priority species per sample	0.6	1.2	1.4	0.8	0.8	0.7	1.4	2.5	1.1

*Land use present in only on community

San José de las Conchas

The samples in the centre and top of the ordination (Figure 3) show little evidence that any particular land use, with the exception of the *solares*, can be distinguished by a distinct set of species. Across all samples, within land use variation is high. The putative regeneration gradient is apparent, with variation along axis 1 being greatest between some *solar* and some woodlot samples.

To the centre right of the scatter plot a group of five samples (three woodlot, one *milpa* and a fallow) are clearly separated. TWINSPAN detected no clear positive indicators for these samples but does select two negative indicators (i.e., species absent from these samples but common to the others): *Crescentia alata* H.B.K. and *Jacquinia macrocarpa* Cav., while *Mimosa platycarpa* Benth. and *Acacia collinsii* Safford also emerged as being strong negative indicators of this group of samples. These four species especially favour open vegetation types, with the latter two being thorny and resistant to browsing.

Los Coyotes

Figure 4 also shows a possible regeneration gradient running along axis 1 with *solares* to the left and woodlots to the right, although both *solar* and woodlot samples are also present amongst the majority of samples clustered in the centre. For the five woodlots, the fallow and the *solar* at the far right of the scatter plot, TWINSPAN selected *Cochlospermum vitifolium* (Willd.) Spreng. and *Bursera simarouba* (L.) Sarg. as positive indicators of this group, with *Citrus simensis* (L.) Osbeck and *Solanum hazenii* Britt. as negative indicators. Again, concentrated in the middle of the scatter plot are the majority of samples amongst which TWINSPAN was unable to detect groups of species indicative of particular land uses.

Communities combined

In Figure 5, San José de las Conchas, a sea level community, is represented by the cluster of samples at the left of the scatter plot. At the opposite end of axis 1, i.e., those least like that of San José de las Conchas, are the samples from San Juan Arriba. San Juan Arriba is the community at the highest altitude and with the shortest dry season. Whilst samples from San Juan Arriba are less clustered than those of San José de las Conchas, it seems that axis 1 is related to

an altitude/rainfall gradient. At the extremes of the axis, variation between communities is greater than variation within communities.

The combined *solar* samples for all four of the communities are in the top half of the scatter plot, whilst the woodlot plots are all at the bottom. This corresponds to the regeneration gradient noted for Figure 1 to 4, this time aligned with axis 2. It is also notable that three of the four combined woodlot samples are quite similar. The *solar* samples are, however, highly variable between communities. This perhaps reflects the fact that householders in the four communities appeared to define a *solar* as much by its location (it is the tree dominated area closest to the house) as by any uniformity of tree husbandry regimes. Coffee plantations, unique to San Juan Arriba, are again shown here not to be particularly distinct in their species composition.

Figure 5 reveals an especially close relationship between fallows, *milpas* and pastures in San José de las Conchas and Agua Zarca. This is despite there being considerable differences both in the management regimes to which these land uses were subject and in the resulting structure of woody vegetation. This is most easily explicable by recalling that these three land uses are interchangeable over time, pasture and *milpa* being periodically left fallow. At the beginning of fallow periods, woody species present as stumps, shade trees and seeds are liberated and come to dominate without there necessarily being a great change in the species composition. On clearing the fallow, that same group of species remains in the *milpa* or pasture either in the seed bank, as stumps or as shade trees. Whilst this relationship is less obvious in the samples from San Juan Arriba and Los Coyotes, the relevant land uses were under-sampled in these communities. Nonetheless for San Juan Arriba, along the left to right, putative altitude/rainfall gradient, these three land uses fall within a narrow band.

Conservation priorities

It might normally be assumed that the rarer species would show a preference for less disturbed vegetation, such as woodlots, and Table 6 shows that this land use type has the highest ratio of priority species to samples (ignoring the under sampled 'other' land use type). However, fallow and *milpa* samples have similar ratios. Further, of the ten species listed only three (*Bunchosia guatemalensis* Ndzu, *Casearia williamsiana* Sleumer, and *Rondeletia deamii* (Donn. Smith.) Standl.) were found to be present proportionally more often in woodlots than in other land uses. In the case of *R. deamii*, to ignore the non-woodlot land uses would be to ignore more than half the samples in which it was found. Furthermore, of the priority species, three were not found in any of the woodlot samples reported here.

Before it is assumed that the species endemic to the dry forest zone must necessarily be threatened by forest conversion, it seems reasonable to ask whether any of that diversity continues to be found in the land uses which have replaced forest. Southern Honduras undoubtedly represents an extreme in terms of the degree of forest conversion. Field observation by the authors suggests that nothing approaching unintervened primary forest remains. Figure 5 suggests that the remaining woodlots of three of the communities do contain assemblages of woody species that are different from the other land uses. However, when the samples are considered community by community, and with the samples of each land use not aggregated, the distinctness of the woodlot samples becomes less clear, woodlot samples appearing amongst the *milpas*, fallows and pastures and *vice versa*. Returning therefore to the first question posed in the introduction, we can say that there is broad similarity between the species composition of the naturally regenerating tree diversity in different parts of the landscape mosaic. The *solares*, because of their high content of planted fruit trees, are relatively distinct but such common species, often exotics, are not the usual focus of conservation. The lack of land use specificity of priority species does suggest that to consider forests, such as the woodlots described here, or indeed any other single land use such as the coffee plantations that have generated much interest in recent years (Perfecto et al. 1996) as the only suitable site for tree diversity conservation would be to overlook a significant part of the resource with which tree diversity conservation might be advanced. This is especially so of species such as *S. humilis*, *E. hondurensis* and *Actinochetia filicina* (D.C.) Barkley whose land use preferences are especially broad. This lack of specificity is not surprising given the secondary nature of these woodlots and the role natural regeneration plays in determining the tree species composition of other land uses from which most of the woodlots are derived.

In answer to the second question posed, it is concluded that this landscape, the southern Honduran dry forest agro-ecosystem, is not an international priority for tree diversity conservation as it contains too few

priority species. No 'black star', one 'gold star' and seven 'blue stars' to a total of 241 identified species compares poorly with broadly similar star ranking carried out for tree diversity in four types of Ghanaian forest by Hawthorne and Abu Juam (1995). This revealed 52 'black stars', 208 'gold stars' and 414 'blue stars' from a total of 1791 identified species[1].

Swietenia humilis

S. humilis merits particular consideration here as the only species in this study whose conservation status is currently recognised internationally by IUCN and also under appendix II of CITES. It was one of the most commonly encountered species in this study, occurring in 50.8% of samples taken and is well represented in all land uses except coffee plantations (Table 6). It would, therefore, appear to be relatively insensitive to land use changes, including woodlot clearance. It can therefore be said that at a landscape level, *S. humilis* is common in southern Honduras, and that drastic reduction in forest cover has not led, and probably will not lead, to its extinction. The locally high timber value of this species ensures that in each of these land uses *S. humilis* is likely to reach reproductive maturity, as farmers actively protect seedlings and saplings until they reach a size suitable for harvesting timber. It is in part its valuable timber (Barrance et al., this volume) and in part its natural affinity for disturbance, that ensures its continued presence in this landscape (Boshier et al., in press). This leads us to question the assumption that felling a species for its timber is detrimental to that species' chances of survival. This assumption, in relation to international markets, is implicit in the listing of *S. humilis* in appendix II of CITES. Given also that it is of wide natural distribution, it might be that its status as an internationally protected species needs reappraising.

Conclusions

The principal value of trees in this area lies in their utility for resource poor farmers, rather than for the contribution they can make to global biodiversity conservation. Conservation initiatives that reduced these use values, such as the prohibition of felling, might cost the farmer dear without providing a good return for the conservationist. Indeed, that return may even be negative if benefits to farmers are curtailed to the point at which they cease to permit or encourage natural regeneration within their farming systems.

Despite the lack of priority species, this ecosystem should not be exempt from the "conservation biologist's lens" (Vandemeer and Perfecto 1997). The continued presence of a large number of woody species reduces concern for their future, at little or no cost to conservation programmes, despite extensive conversion of the original forest type. If these species can be shown to be safe in such agro-ecosystems then conservation resources can be directed to areas where there are other species of narrower distribution and greater habitat specificity. Here, the lack of land use specificity shown by these species, along with the limited information available on geneflow patterns in this agro-ecosystem (White and Boshier 2000), allow us to be cautiously optimistic that they will be conserved so long as land management practices continue to favour natural regeneration.

It remains to be seen whether other agro-ecosystems will prove to contain greater numbers of priority species than the one discussed here, or whether they similarly represent a largely cost free long-term option for a great many other species. It may be that landscapes that contain significant areas of mature vegetation will prove to have a greater proportion of priority species than the landscape discussed here. Certainly, in southern Honduras, the case for the use of protected areas and restoration ecology (Janzen, 1988b) as routes to dry forest tree diversity conservation should be questioned given the lack of reservoirs of especially rare diversity. Current efforts to establish part of the Mesoamerican Biological Corridor through southern Honduras may therefore provide limited returns for tree diversity conservation. The few priority species that do exist in this area require attention on a case-by-case basis, without recourse to protected areas that would restrict farmers' activities. As Hellin and Hughes (1993) show for *L. salvadorensis,* for such species the key may be the promotion of species' uses and farmers' traditional management practices.

Note

1. Botanical surveying (to be reported elsewhere) of identical methodology and of a similar number of samples as that described here and carried out by the authors in the dry forest zone of Oaxaca, Mexico revealed 10 'black star' species, 22 'gold star' species

and 35 'blue star' species from a total of just over 300 species.

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RESEARCH PAPER

Are rare species useful species? Obstacles to the conservation of tree diversity in the dry forest zone agro-ecosystems of Mesoamerica

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ABSTRACT

Aim To test the potential to conserve rare dry forest tree and shrub species *circa situm*.

Location Oaxaca, Mexico and Southern Honduras.

Methods Local uses (timber, posts and firewood) of species were determined principally through semistructured interviews with 20 rural householders in each of four communities in Honduras and four in Oaxaca. Tree and shrub diversity inventories were carried out in a total of 227 forest patches and parcels of farmland in those eight communities. Species' conservation priorities were determined using the star system of Hawthorne (1996) and IUCN listings.

Results Despite a large number of useful species, remarkably few were also conservation priorities. Useful species were found to be substitutable as is illustrated by *Bombacopsis quinata*, *Cordia alliodora*, *Guaiacum sanctum* and *G. coulteri.*

Conclusions In these areas, *circa situm* conservation is inhibited by the lack of species that are both rare and useful. Usefulness must be interpreted as a function of substitutability. Natural regeneration provides an abundance of diversity, farmers are unlikely to invest in the management of a species when suitable substitutes are freely available. The key to conserving rare species may be in maintaining or enhancing the value of the landscape elements in which they are found.

Key words *Bombacopsis quinata*, *circa situm* conservation, *Cordia alliodora*, *Guaiacum*, Honduras, Oaxaca, tropical dry forest.

INTRODUCTION

As tropical forest conversion continues, with its associated loss of biodiversity, increasing attention is being paid to a varied set of components in tropical landscapes that may be potential sites for conservation (Halladay & Gilmour, 1995; Pagiola *et al*., 1997; Vandemeer & Perfecto, 1997). It is accepted that certain agricultural practices support a wide range of species and that a significant fraction of forest diversity may therefore be maintained outside of mature forests. Examples of this relating to Mesoamerican tree diversity include kitchen gardens in Belize (Steinberg, 1998), pasture in Costa Rica (Harvey & Haber, 1999) and in Mexico (Guevara, 1995), coffee in Mexico (Moguel & Toledo, 1999) and secondary forest in Costa Rica (Finegan & Delgado, 2000). Tropical conservation is now about more than just strictly protected areas, crucial though they will continue to be where ecological and socio-economic conditions permit.

A simplistic but useful distinction can be drawn between two approaches to maximizing the conservation potential of such modified landscapes, while recognizing that elements of both approaches may be appropriate in a single location. One is referred to as restoration ecology (Janzen, 1988a; Jackson *et al*., 1995) and involves the transformation of modified habitats into ones considered more like that of their predisturbance state. In effect this means allowing natural processes of recovery to dominate areas affected previously by anthropogenic processes. The second approach seeks less to transform the composition and structure of existing diversity in a modified landscape, but more to maximize its potential. It thus seeks compatibility between current and future human activities and biodiversity. Aspects of this second approach, known as *circa situm* conservation, are considered here.

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The characteristics of *circa situm* conservation are that species are maintained within their natural ranges and climatic zones, but in habitats different from those in which they are assumed to have spent most of their evolutionary history. In practice this often means conserving forest species in the agricultural landscapes that have replaced natural forests. For further discussion of this approach see Hughes (1998) and Boshier *et al.* (in press).

Conservation within agricultural landscapes necessitates a tolerance of existing agricultural practices and other productive activities. To minimize the disruption that may be caused to those making a living from the land, interventions need to be precisely targeted at the priority biodiversity within the landscape so that concern for particular species does not translate into general restrictions on productive activities. One approach to this is to identify species that are both of conservation concern and are useful (or potentially useful) to farmers, and hence propose interventions that ensure or enhance the conservation of those species through their continued use.

The Mesoamerican dry forest, which is the subject of this paper, is an appropriate place to consider this approach given its high level of conversion and fragmentation (Janzen, 1988b; Lerdau *et al.*, 1991) and the continued use of native trees by farmers in the zone. Boshier *et al.* (in press) have discussed *circa situm* conservation in this biome with particular reference to gene flow between fragmented populations of trees in southern Honduras. Here we develop some themes related to that discussion, using examples from the dry forests of Honduras and Oaxaca, Mexico. In particular, we discuss the lack of congruence between lists of restricted range species and lists of species of local socio-economic importance, and also the ease with which farmers' tree preferences alter as circumstances change.

METHODS

In order to identify species that might be conserved *circa situm*, surveys were carried out in tropical dry forest zones of southern Honduras and coastal Oaxaca, Mexico during the period from 1998 to 2000. These predominantly rural areas were chosen as case-study sites because they both fall within the band of seasonally dry tropical life zone that predominates on the Pacific coast of Central America and Mexico, but vary in the degree to which the native tropical dry forest has been fragmented and converted. The agricultural matrix that dominates in southern Honduras now has virtually no mature tropical dry forest (see, e.g. Durham, 1979; Stonich & DeWalt, 1996), while in parts of coastal Oaxaca there remain in the landscape some relatively extensive areas of mature dry forest (see, e.g. Nahmad *et al.*, 1994). Eight rural communities, four in each country, were the foci of the study. These were selected non-randomly in order to represent approximately the diversity of social and biophysical conditions in each study area: in Honduras they ranged from communities with good market access in higher, moister areas, to more isolated communities in lower, drier areas; in Oaxaca they included agrarian communities and *ejidos* with widely varying degrees of forest protection and market access. Besides patches of mature and secondary forest the other land uses encountered, although not necessarily in all the communities, were pasture, basic grain fields (*milpas*), tree-dominated fallows, low-intensity coffee plantations, small orchards and home gardens (*solares*). Two types of survey were carried out: one, a socio-economic survey, sought to identify and describe local use of trees by members of farming families; the other, a tree and shrub diversity survey, inventoried species across a range of land uses in the same communities and categorized those species according to the degree of threat they faced globally.

For the socio-economic surveys semistructured interviews were carried out with members of 20 farming families in each of the eight communities, selected randomly within socio-economic strata defined according to criteria established by community members (the principal criterion used was land holding size). Interviewees were asked to describe on-farm tree usage, rank species according to preference for each use and describe how the species were managed in the agro-ecosystem. Where the opportunity arose, these interviews were extended to visits to farmers' fields, while focus group meetings with different sectors of the population were used to discuss specific themes. It is important to note that interviewees were not presented with a species list and asked to name uses, as the answers might not have reflected the true importance to them of a given species for a particular use (almost any species can be used for firewood and the mention of medicinal properties does not necessarily reflect the degree to which it is currently used for that purpose). Rather, they were asked to list the main species that they used for a subset of uses (timber, posts and firewood). The frequency of repetition of mention of a species between interviewees was taken as a measure of its socio-economic importance. The frequency of mentions for each species for a given use was subsequently weighted according to the total number of species mentioned for that use, in order to reflect the degree of substitutability of each species for each use. Hence, the more species mentioned for each use, the less important (more substitutable) each species in that use group became. This rapid form of ranking species' use values permitted work with a great number of species across several communities that more direct measures of value would not have allowed within the time-frame of the research.

The botanical surveys were based on checklists of woody perennials compiled from a cross-section of land uses, chosen non-randomly to reflect land use diversity within and between each of the eight communities. This survey was conducted with the assistance of local tree spotters and largely

contemporaneously with the socio-economic survey to facilitate the matching of common names to scientific names. However, occasional difficulty due to working with sterile material and the lack of perfect consistency between common and scientific names resulted in a few common names not having scientific matches. Vouchers from the survey were deposited either in the National Herbarium of the Autonomous University of Mexico (MEXU) or in the Paul C. Standley Herbarium of the Pan-American Agricultural School, Honduras (EAP). Each checklist represented approximately 4.5 person-hours of searching in a particular area, which for many of the smaller parcels of land surveyed resulted in a total inventory, all species present in the parcels having been identified or collected before this time was complete. The species thus identified were then classified according to IUCN listings (Oldfield *et al*., 1998) or, because very few Mesoamerican dry forest trees have so far been classified in this way, by a modified version of the star system (Hawthorne, 1996). Both systems share the basic principle that the species that most require conservation attention (i.e. have highest conservation value) are those that are most threatened. For the star system, species were put into one of four categories depending upon their range sizes, thus range size is considered a surrogate of threat and the smaller (more restricted) the species' range, the higher the priority. The most restricted range species, those endemic to the dry forests of either coastal Oaxaca or southern Honduras, were given the rank of 'black star species' denoting the highest priority for global conservation. The next rank, gold star species, were those endemic to Mesoamerican Pacific dry forest and limited to between two and four Mexican states/Central American countries. Blue star species, the next rank down were *either* found in two to four states/countries but were not endemic to Pacific dry forest *or* were found in five to eight states/countries and were endemic to Pacific dry forest. All other species (green stars) were considered to be too widespread to be priorities. Hawthorne (1996) refines the star system using secondary criteria that reflect current and future economic values of species but which, in the context of this study, detract from the primacy of identifying species at risk of global extinction. He also uses information on habitat preference to adjust species' star rankings, but a lack of this type of information for most of the species encountered meant that this refinement was also not used here.

In the absence of detailed information on population structures and rates of decline for the vast majority of the over 450 species identified in the surveys, this approximation of threat was considered the only practical alternative to IUCN classifications.

Species range size was determined principally from herbarium records in the herbaria mentioned above. This information was supplemented by taxonomic monographs, where available, and data from online databases.

RESULTS AND DISCUSSION

The botanical survey consisted of 227 samples (138 in Honduras and 89 in Oaxaca) in which 6672 records of trees were made. Of these records, 6267 were identified to species (94% of total) resulting in 454 species in total, 231 from Honduras and 324 from Oaxaca.

In the socio-economic survey, a total of 131 tree species were mentioned as used in Oaxaca and 150 in Honduras. These figures do not necessarily represent the precise number of species mentioned due, especially in Oaxaca, to occasional difficulty, noted above, in relating common names with confidence to scientific names.

Low congruence between rare species and useful species

Table 1 contains all the identified species considered, by the two criteria used, to be of some degree of global conservation concern. However, in agreement with Pennington *et al*. (1981) and Boshier *et al*. (in press), we question the 'vulnerable' status of the widespread and freely regenerating species *Swietenia humilis* Zucc. (Meliaceae), and do not treat it as a priority species here. The remaining 45 species are therefore the tree conservation priorities in the eight communities surveyed.

Just two of the 36 priority species in Oaxaca (5%) and two of the nine in Honduras (22%) were mentioned by the farmers interviewed as being used (these are highlighted in bold in Table 1). Conversely, less than 2% of the species mentioned as used in either Oaxaca or Honduras are of conservation priority (Table 2). Thus, in both coastal Oaxaca and southern Honduras, areas which differ greatly socio-economically and that also present different levels of forest fragmentation and conversion, there is little congruence between lists of globally rare species and lists of locally useful species.

In southern Honduras this is explicable by a very low number of priority species in the landscape. In coastal Oaxaca, where more priority species are found (36 of the total of 45), such species are rarely used. It appears that in the circumstances of these landscapes, the species that are preferred by farmers are not global conservation priorities.

High substitutability between useful species

Despite the relative lack of species of both local utility and with restricted range, it is useful to consider the potential for *circa situm* conservation of at least one species that does fall into both categories.

Bombacopsis quinata (Jacq.) Dugand (Bombaceae) is a valuable timber species of seasonally dry regions from Colombia and Venezuela to Honduras. While this relatively broad distribution means that it is not, as a species, in critical

Table 1 Priority species found in the eight communities surveyed, listed by country. Species marked * are those found principally in mature forest patches. Species marked in bold were mentioned as being used by local people

Black star species: Oaxaca

Achatocarpus oaxacanus Standl. Achatocarpaceae*
Castela retusa Liebm. Simaroubaceae*
Jatropha alamani Muell.Arg. Euphorbiaceae*
Jatropha sympetala Standl. & Blake Euphorbiaceae*
Waltheria conzatii Standl. Sterculiaceae

Gold star species: Oaxaca

Bourreria purpusii Brandgee Boraginaceae*
Brongniartia bracteolata* Micheli Papilionaceae
Bucida wigginsiana Miranda Combretaceae*
Caesalpinia hughesii G.P. Lewis Caesalpiniaceae*
Capparis angustifolia Kunth Capparidaceae*
Forchhammeria lanceolata Standl. Capparidaceae*
Guettarda galeottii Standl. Rubiaceae
Lonchocarpus emarginatus Pittier Papilionaceae*
Lonchocarpus longipedicellatus Pittier Papilionaceae*
Physodium oaxacanum Dorr & Barnett Sterculiaceae
Randia cinerea (Fernald) Standl. Rubiaceae
Recchia mexicana Moc. & Sessé Simaroubaceae*
Sapranthus foetidus (Rose) Saff. Annonaceae*

Gold star species: Honduras

Eugenia hondurensis Ant. Molina Myrtaceae
Casearia williamsiana Sleumer Flacourtiaceae
Grajalesia fasciculata (Standl.) Miranda Nyctaginaceae
***Leucaena salvadorensis* Standl. Mimosaceae**

Blue star species: Oaxaca

Abutilon grandidentatum Fryxel Malvaceae*
Bucida macrostachya* Standl. Combretaceae
Calliandra hirsuta (G.Don) Benth. Mimosaceae
Croton axillaris Muell.Arg. Euphorbiaceae*
Croton ramillatus Croizat Euphorbiaceae*
Gyrocarpus mocinnoi Espejo Hernandiaceae
Havardia campylacanthus (L. Rico & M. Sousa) Barneby & J.W. Grimes Mimosaceae
Heliocarpus occidentalis Rose Tiliaceae*
Hibiscus peripteroides Fryxell Malvaceae
Hyptis tomentosa Poit. Labiatae
Lagrezia monosperma (Rose) Standl. Amaranthaceae
Lonchocarpus constrictus Pittier Papilionaceae*
Mimosa eurycarpa B.L. Rob. Mimosaceae*
Mimosa robusta R.Grether Mimosaceae
Montanoa tomentosa Cerv. ssp. *microcephala* (Sch.Bip.) V.A. Funk Compositae
Rondeletia deamii (Donn.Sm) Standl. Rubiaceae
Torrubia macrocarpa Miranda Nyctaginaceae*
Verbesina oaxacana DC. Compositae

Blue Star species: Honduras

Actinocheita filicina (DC.) F.A. Barkley Anacardiaceae
Mimosa panamensis (Benth.) Standl. Mimosaceae
Randia pleiomeris Standl. Rubiaceae
Rondeletia deamii (Donn.Sm) Standl. Rubiaceae

IUCN classifications

***Bombacopsis quinata* (Jacq.) Dugand.** Bombacaceae*: vulnerable
***Guaiacum sanctum* L.** Zygophyllaceae: endangered

Table 2 Species identified as conservation priorities that were also mentioned as being used by interviewees

Species	Status	Socio-economic use
Brongnartia bracteolata	Gold star (Oaxaca)	Mentioned by five of 80 interviewees (6%) as used for timber
Leucaena salvadorensis	Gold star (Honduras)	Not found in Honduran tree surveys of communities studied but used and protected as a source of durable posts where it is found
Bucida macrostachya	Blue star (Oaxaca)	Mentioned by only one interviewee as used for timber
Bombacopsis quinata	IUCN vulnerable (Honduras)	Among the 10 species most mentioned as used for timber in Honduran study communities

danger, it is considered vulnerable by the IUCN (Oldfield *et al*., 1998). Furthermore the conservation of its genetic diversity is considered important as the raw material for future tree improvement and populations in southern Honduras, being at the northern extreme of the species' natural range, may store genetic diversity unique to the species. In one of the communities surveyed in southern Honduras, Los Coyotes in El Triunfo municipality, the tree is especially valued because a market for its timber exists in the nearby town of El Triunfo where furniture making is an important local industry. Thus,

in this community it is found within its natural range but in a habitat different from that in which it is assumed to have spent most of its evolutionary history, making these populations suitable candidates for *circa situm* conservation.

Close inspection of the dynamics of the agricultural system in which it is located reveal that this promise may not be easy to fulfil. The species is only one of a number which are used as a source of timber, both for subsistence and for sale, and although it is one of the most valuable of those timbers in local markets, the species does not regenerate as freely in this landscape as other suitable timber species such as *S. humilis*, *Guazuma ulmifolia* Lam. (Sterculiaceae) and *Cordia alliodora* (Ruiz & Pav.) Oken (Boraginaceae). In a focus group meeting, farmers described how overexploitation of *B. quinata* has led to them substituting it with a group of eight different species, which they now sell in El Triunfo despite the inferior timber quality of several of those species (such as *G. ulmifolia*). While this local provenance of *B. quinata* may be a unique global resource for the conservationist and the tree breeder, for the local farmers it is only one of several species that produce good timber. Farmers are happy to substitute one species for another depending on socio-economic and ecological conditions; in this case *B. quinata* appears to be losing out to the far more freely regenerating *C. alliodora*. This latter species, the most commonly encountered in the Honduran communities surveyed, regenerates naturally and abundantly in fields, pastures and secondary forests, thus providing farmers with a cost-free stock of seedlings and saplings. Furthermore, its narrow crown makes it more compatible with the crops among which it is nurtured. Despite the demand for *B. quinata*, ease of supply of *C. alliodora* has now made the latter species one of the dominant timbers on the local market. Attempts to stimulate greater production of *B. quinata* in the region through artificial means of regeneration (it can be grown from stakes) will always be handicapped by the almost cost-free natural regeneration of *C. alliodora* (it is recognized that natural regeneration does incur an opportunity cost with respect to the reduction of crop area its use entails).

This willingness to substitute species is even more pronounced in the case of fuel-wood. Although farmers distinguish between the different qualities of several fuel-wood species, they continue to use a large number regardless of these preferences; a total of 64 species in southern Honduras and 57 in Oaxaca were mentioned. Their choice appears to be determined more by availability and closeness to home than by quality. Although many of the species (53% in Honduras) are used for more than one purpose, and thus might be defined as multiple-use trees, the secondary use, most typically firewood, tends to be more an incidental result of the progressive thinning out of timber species, or the use of sawing residues for firewood, than of an active preference for species for timber and firewood at the same time. Thus the depletion of populations of one fuel-wood species in the landscape, whether it be of a globally rare species or not, is unlikely to provoke changes in management in favour of survival of that species. Instead one of many substitute sources of fuel-wood is likely to be used in its place.

Substitution may also explain the apparent lack of one species native to this forest type in Honduras and of known value. *Guaiacum sanctum* L. (Zygophyllaceae) was found at low frequency in surveys of forests outside of the communities surveyed (Gordon, unpublished data) but not within any of them. It is easily recognized and known for the valuable timber it produces, as well as having many documented medicinal properties (Grow & Schwartzman, 2001). For these reasons it has long been exploited, often having been selectively removed from the forest, and is therefore classified as 'endangered' by IUCN. Those individual trees still found are usually well below sizes considered suitable for commercial harvesting. It is a slow-growing species with a tendency to low branching and lateral spreading when grown in the open. These properties do not make it suitable for short-rotation fallow systems and for integration in crop fields and pasture. Further, the time and effort needed to produce a timber crop from this species probably outweighs any benefit from the high value of the timber. Farmers, understandably therefore, have long turned to the more suitable if less valuable species already mentioned. Thus, while it can be argued that farmers protect a great many species that are valuable to them, it will not necessarily be true for all species. The long-term maintenance of this species in southern Honduras must be considered doubtful given its rarity in the remaining secondary forest patches of the region.

A similar situation exists for a congener of this species, *G. coulteri* A Gray. This species, which shares many characteristics of *G. sanctum* including slow growth and valuable wood properties, is found in the dry forests of Oaxaca where *G. sanctum* is not. It is used locally for construction but is rarely, if ever, found as individuals of greater than 40 cm diameter at breast height. It was found in 10 of the 86 samples taken in Oaxaca. Of those samples, six were from mature forest patches while three and one were, respectively, from fallows and a pasture near those mature forest patches. While currently still sporadically common, this species may also be one whose long-term conservation cannot be guaranteed by *circa situm* conservation despite its recognized local value.

CONCLUSIONS

The comparison of species' utility presented here refers to only three types of use (firewood, timber and posts), whereas in reality farmers obtain many more products and services from trees. However, neither in Oaxaca nor Honduras would the inclusion of additional forms of use in the analysis have affected the overall conclusion that rare species are generally

not useful species. Hence we conclude that in the two areas studied, *circa situm* approaches, which depend on species' individual use values, have limited applicability as a conservation strategy for rare species. Furthermore, we emphasize that the use value of a species, rare or not, is a function not only of the products or services which it may provide, but also its substitutability. This in turn is a function of its regeneration requirements, its growth habit and the availability of it and its potential substitutes. All these factors will interact with local land management practices in a context specific manner. Even for medicinal uses, for which it might be assumed that specific ailments might have species specific cures, the possibility that substitute products (whether derived from trees or elsewhere) represent a cheaper option must be discounted before such species are promoted as part of conservation or rural development agendas. Certainly, we found no evidence of a desire among farmers in Honduras to regenerate *G. sanctum* artificially for its medicinal properties.

Our general conclusions are equally likely to apply to 'multiple-use' tree species. The loss of a particular species of more than one use from a community cannot be taken to imply that farmers' investment in its reintroduction will be worthwhile if similar products are available from different but locally abundant naturally regenerating species.

Because of the very low numbers of priority species found in the surveys carried out in southern Honduras, discussion about the lack of opportunities for promoting the *circa situm* conservation of globally important tree diversity becomes a discussion about the lack of restricted range species there. The dry zone of southern Honduras is now almost completely converted from mature forest to a mosaic of agricultural and livestock uses with occasional secondary forests and fallows. It is therefore possible that the lack of such species is explicable by the phenomenon of *biotic homogenization* (McKinney & Lockwood, 1999). Its implication is that restricted range species, perhaps species previously of mature forest, have now been replaced by 'a much smaller number of expanding species that thrive in human-altered environments' (McKinney & Lockwood, 1999). This is supported by the observation that, of the restricted range species from Oaxaca listed in Table 1, the majority showed a preference for patches of mature forest and associated long rotation fallows.

This does not necessarily imply that *circa situm* conservation is not an option for southern Honduran tree diversity. However, given the high requirements for both socio-economic and ecological information relating to each species conserved in this way (Boshier *et al*., in press), *circa situm* conservation as discussed here is probably only ever likely to be applied to very few species, such as *Leucaena salvadorensis* Standl. (Mimosaceae) (Hughes, 1998).

The communities studied in coastal Oaxaca do, however, contain restricted range species. Whether *circa situm* conservation is applicable here will depend on the relationship between the land-uses represented in these communities and the more extensive tracts of dry forest outside of these communities. It may be most appropriate to conserve these species in those tracts of forests, i.e. *in situ*, relying wherever possible on the motivation provided by use values of the forest as a whole (for example, hydrological and tourist services). However, should they not be represented adequately in those forests, *circa situm* conservation elsewhere in the landscape, especially the long-rotation fallows, may be an important complementary strategy. If so, the lack of local utility generally ascribed to the priority species will require a reformulation of *circa situm* conservation away from the species specific approach considered here, towards one which is more landscape-oriented. That is to say, strategies would have to be based on maintaining or enhancing the existing land management practices within which these species can incidentally co-exist. In the case of both Oaxaca and southern Honduras this requires recognition of the importance of naturally regenerating tree diversity in farming systems and an appreciation that clearing fallow is not necessarily harmful to biodiversity providing that approximately equivalent areas of fallow are maintained in the landscape overall.

In Honduras the trend in recent years, related to population increase, appears to have been towards a reduction in fallow cycle length and forest sizes; none the less, the natural regeneration of trees continues to be an important part of the management of fields and pastures. In much of coastal Oaxaca, despite recent legal changes making land 'privatization' possible, communal forms of management still dominate that have the effect of controlling the number of people dependent on a given area of land. Furthermore, returns on agricultural investment are currently relatively unattractive compared to out-migration and the opportunities offered in some areas by alternatives such as the tourism industry. Hence, widespread intensification of agricultural practices is not currently in evidence. There therefore appears to be a reasonable prospect that significant areas of forest and forest fallow will be maintained for the foreseeable future making a conservation strategy which combines *in situ* and *circa situm* approaches a promising option.

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Assessing landscapes: a case study of tree and shrub diversity in the seasonally dry tropical forests of Oaxaca, Mexico and southern Honduras

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Abstract

Tropical dry forests, with their distinct and economically important diversity, are acknowledged conservation priorities because of alarming rates of forest conversion. Whilst it is realised that terrestrial conservation requires an understanding of landscape level patterns of diversity, forests are rarely assessed accordingly. Here we demonstrate that, in the case of the seasonally dry tropical forests of the Pacific watershed of Mesoamerica, landscape level assessment of woody diversity can inform decision making relevant to both between-landscape and within-landscape prioritisation. We report floristic surveys of dry forest landscapes in Oaxaca, Mexico and southern Honduras. It is noted that these forests are floristically similar to other seasonally dry tropical forests in the neotropics. By calculation of Genetic Heat Indices, a relative measure of the concentration of restricted range species in a sample, we determine that the conservation of the tree diversity of the coastal lowlands of Oaxaca should be prioritised over that of southern Honduras. The current conservation status of forested areas in Oaxaca is briefly described. We suggest that the greater degree of anthropogenic disturbance in southern Honduras may explain the relative lack of restricted range species there. We argue that some forest fallows can act as analogues of mature forest and therefore landscape elements other than mature forest need to be included in forest conservation assessments. We conclude that diversity sampling of any forest type should not be limited to mature forests, but extended to other elements of forested landscapes.
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Keywords: Forest conservation; Forest fragmentation; Forest fallow; Biodiversity

1. Introduction

Seasonally dry tropical forests (SDTFs) rank amongst the most endangered of terrestrial ecosystems (Lerdau et al., 1991) with those of Mesoamerica (southern Mexico and Central America) being of particular concern. Janzen (1988a), writing of these forests in Central America, estimated that less than 2% of the original forest is in a state 'sufficiently intact to attract the attention of the traditional conservationist', with only 0.09% at that time having official reserve status. More recently, Trejo and Dirzo (2000) calculated that by 1990 only 27% of the original area of Mexico's SDTF remained.

The fragmentation (Casante et al., 2002; Boshier et al., in press) and conversion (Maass, 1995) of the original forest cover, which was begun in pre-Columbian times and continues today, has put at risk a distinct woody flora (Gentry, 1992) of high socio-economic importance. This importance is derived as much from the use local inhabitants make of native tree resources (Bye, 1995), as from the use to which these species have been put elsewhere in the world. Important taxa native to Mesoamerican SDTF, and now in use on other continents or whose products are traded internationally,

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include *Leucaena* (Hughes, 1998); *Guaiacum* (Grow and Schwartzman, 2001), *Gossypium* (Fryxell, 1979); *Swietenia* (Mayhew and Newton, 1988); *Cordia alliodora* (Ruiz. & Pavon.) Oken (Boshier and Lamb, 1997) and *Gliricidia sepium* (Jacq.) Steudel (Stewart et al., 1996). The conservation of Mesoamerican SDTF can therefore be considered an international priority both as a unique ecosystem and as a store of genetic variability of proven current value. However, not all SDTF in the region is the same and species composition varies (Gentry, 1995; Gillespie et al., 2000; Trejo and Dirzo, 2002) as would be expected across a region of high biophysical and socio-economic variability. This variability is also reflected in the many land-uses which make up a typical SDTF landscape following its fragmentation and conversion. In these circumstances biodiversity assessment, both within and between landscapes, is an essential tool for aiding the rational selection of sites, however, typically only forests considered well conserved or mature are subject to assessment (e.g. Lott et al., 1987; Trejo and Dirzo, 2002). Here we report a comparative study of the tree and shrub diversity of two lowland SDTF landscapes on the Pacific watershed of Mesoamerica, and discuss the significance of the results in relation to conservation priorities. The yardstick by which we compare mature forests, secondary forests and forest fallows is their relative content of species considered to be threatened by global extinction.

We use the term seasonally dry tropical forest in the broad sense of Mooney et al., (1995). Within this broad definition we distinguish two types of SDTF in the samples discussed here. Dry deciduous forest has a closed canopy reaching rarely more than 15 m in height and in which over 75% of canopy species are leafless during the dry season; this definition being equivalent to the term *bosque bajo caducifolio* in the classification of Rzedowski (1981) which is commonly used in Mexico. Dry semideciduous forest has a closed canopy reaching to 20 m height and in which between 50 and 75% of trees are leafless during the dry season, a definition which corresponds to term *bosque mediano subcaducifolio* of Rzedowski (1981). The differences between these forest types are assumed to be primarily determined by water relations, the latter has a shorter dry season and higher annual rainfall, but annual rainfall in SDTF areas is highly variable (Murphy and Lugo, 1986), and soil conditions are also likely to play a role (Mooney et al., 1995). Certainly the vegetation and structure of these forests appear to vary considerably over quite short distances, suggesting a complex set of environmental and anthropogenic factors are in play.

Two stages of sampling are described. The first is a comparison between the forests of southern Honduras and those of coastal Oaxaca, Mexico. The second is a comparison between the forests and the forest fallows of two agrarian communities in coastal Oaxaca.

2. Methods

2.1. Site selection

The lowlands of the Pacific watershed of Mesoamerica once contained probably the largest continuous area of SDTF in the region, stretching from the province of Guanacaste in northern Costa Rica to Baja California Sur in northern Mexico. The two case study areas chosen for this study, the Pacific coast of Honduras and the coast of Oaxaca in southern Mexico, form part of that area of SDTF, but their landscapes demonstrate important differences. In Oaxaca some relatively large areas of mature SDTF remain, whilst in Honduras forest is limited to small patches of secondary forest or woodlots that often measure no more than a few hectares, and never more than a few hundreds of hectares. The survey therefore contains samples from forests of highly variable size. Socio-economically, both areas are notable for their levels of poverty, ranking amongst the poorest in their respective countries. However there are important differences in social organisation. In coastal Oaxaca, which has lower human population densities than southern Honduras, communal land tenure is common whilst in Honduras land is typically privately owned.

Forests sampled in these surveys where chosen non-randomly to maximise coverage of forested areas and with a bias towards forested areas of larger size. The locations of samples are shown in Fig. 1.

Much of the forests of Oaxaca are embedded in a matrix of other land-uses particularly forest fallows which make up a considerable, but to our knowledge undetermined, proportion of the closed canopy woody vegetation of the region. The second stage of the analysis presented here considers the potential for these forest fallows to contribute to woody diversity conservation. The distinction drawn here between forest fallow and secondary forest is essentially a socio-economic one. Secondary forests are areas that have been converted from more intensive forms of land management and, given current socio-economic conditions, are likely to remain forested for the foreseeable future. Fallows remain part of the agricultural cycle and can be expected to be converted to more intensive forms of agricultural production at some point in the future, so long as current socio-economic conditions prevail.

The two communities in Oaxaca whose forest fallows were surveyed were chosen from four communities that formed part of a wider socio-economic survey of tree use in the area. The first of the two, La Jabalina, represents a group of farm dwellings among several dispersed communities or *rancherías* that contain areas of forest and forest fallow, much of it under communal tenure, around the watershed of the Tangolunda River. This area is compared below to forests immediately to their

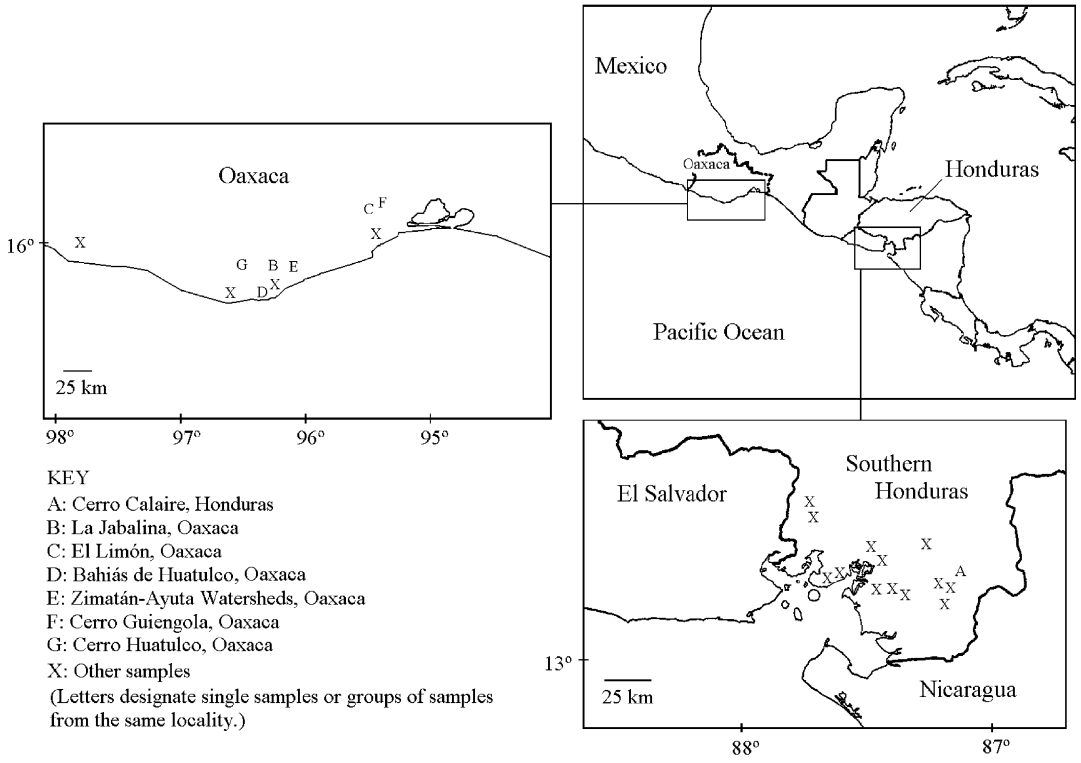

Fig. 1. Location of plant diversity samples: Oaxaca and Honduras.

west in the several watersheds between the Zimatán River and the Ayuta River. Many of the human inhabitants of La Jabalina are relatively new arrivals having been relocated from land expropriated for the nearby Bahías de Huatulco tourist development. The sandy soils and flat to undulating topography of La Jabalina contrast with the more accidented and rocky topography of the Zimatán-Ayuta watersheds. The second community, El Limón, is approximately 100 km northeast of La Jabalina. The land controlled by this long established community is under communal tenure. The sandy soils and undulating terrain within El Limón contrast with the steep slopes and rocky outcrops of Cerro Guiengola, 15 km to its east and with which it is compared.

The two communities were selected not because they were considered representative of coastal Oaxaca but because they contained significant areas of forest fallow in the proximity of forest areas that were determined to be of conservation importance (see below). Samples sites in these two communities were also selected non-randomly depending upon the degree of accessibility granted by members of those communities.

2.2. Sampling

Sampling followed the plotless, rapid botanical survey methodology described by Hawthorne and Abu-Juam (1995) with minor modifications described below. This methodology was chosen because of its speed and efficiency, compared to plot based methodologies, for broad scale assessments across structurally diverse landscapes. It sacrifices detailed information on vegetation structure for landscape level information on species composition eliminating the 'bias' inherent in ignoring species seen in the forest but not present in a plot (Vanclay, 1998). In the case of small forest patches each sample site was delimited by the pre-existing boundaries of the forest. In larger forest patches where distinct forest types could be identified by visual inspection, for example where hillside forest and riverine forest were contiguous, each forest type was surveyed separately. Each sample consisted of a species inventory derived from 4.5 person-hours of searching. In each survey a species was scored as present if it could be identified as a woody individual with a stem diameter at ground level of at least 2 cm, resulting in a very broad definition of woody vegetation and allowing the inclusion of live stumps. Woody climbers were not included in the analysis except those species that were found to have both climbing and shrub habits.

Many of species could be identified in the field, for those that could not specimens were taken, often of sterile material, for later herbarium identification. Oaxacan specimens were identified in the National Herbarium, Mexico City (MEXU) whilst Honduran specimens

were identified in the Paul C. Standley Herbarium, El Zamorano (EAP). Voucher specimens were left in these respective herbaria.

2.3. Determination of species conservation status

The conservation status of each species identified was determined by estimation of its natural distribution; therefore range size is taken to be a surrogate of extinction risk with those species occupying smaller ranges deemed more at risk of extinction than those of greater range size. This may appear to be an over simplification; abundance per unit area, rate of habitat loss and other factors are often considered when evaluating the threat status of a tree species (Oldfield et al., 1998), however for most of the 375 species dealt with such information is simply not available. We thus employed the terminology of Hawthorne (1996) assigning each species to one of four star categories based solely on this parameter (Table 1). The most narrowly distributed species were put into the *black star* category, then follow the *gold star* and *blue star* categories for species with increasing distributions but whose status is still of concern. Finally the *green star* category was used for those of no conservation concern. The distributions were determined principally from herbarium specimen data but also from monographs, reliable checklists (e.g. Janzen and Liesner, 1980; Lott, 1993; Martin et al., 1998) and from on-line databases such as w^{3}Tropicos (accessed 2002). Given the variable quality of information on herbarium specimen labels, the number of Mexican states/Central American countries in which a species had been collected was the imprecise, but practical, unit of measurement used for estimating distributions.

Hawthorne (1996) introduces other variables into the categorisation of species by stars which are not used here. His economic index, which reflects a concern for timber production not inherent in the current context, was based on detailed forest inventory data not available to us. He also increased the importance (i.e. moved up a star category) of species congeneric with species of high current socio-economic importance on the basis that they have greater potential for future use. We omitted this from the current analysis as the same argument could be applied to many other species, (e.g. many woody species have the *potential* to become marketable species) and detracts from the fundamental objective of the current study, that is, the identification of endangered species, and the sites in which they are found *regardless* of their socio-economic importance, either potential or actual. See Appendix for the complete list of priority species found in the samples discussed here.

2.4. Calculation of relative area of occupancy of species of each star category

After surveying and species categorisation, the next step in the methodology was to assign a numeric weight to each star category inversely proportional to the average area occupied by species in that category (Table 2). This weighting then allowed a mean score to be calculated for each sample. These average areas were estimated from the subset of species in each star category (about 10%) for which there were detailed distribution maps published in recent monographs. The unit of measurement of area was the degree-square with the distribution of each species being the total number

Table 1
Categorisation by *stars* of seasonally dry tropical forest (SDTF) tree and shrub diversity from southern Honduras and coastal Oaxaca, Mexico

Criterion	Rank
Endemic to the Pacific SDTF zone of Honduras or Oaxaca	Black star
Endemic to the Mesoamerican Pacific SDTF zone and present in two to four Central American countries/Mexican states	Gold star
Endemic to the Mesoamerican Pacific SDTF zone and present in five to eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific SDTF zone but present in one to four Central American countries/Mexican states	Blue star
Endemic to the Mesoamerican Pacific SDTF zone but present in more than eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific SDTF zone and present in five or more Central American countries/Mexican states	Green star

Table 2
Calculation of weightings for star categories

	Black star	Gold star	Blue star	Green star
Area of occupancy (Mean no degree squares: x)	1.67	4.5	10.33	53.68
$x/53.68$ ($=y$)	0.031	0.084	0.192	1
$1/y$	32.14	11.93	5.19	1
Weighting	32	12	5	0

Table 3
Summary statistics of seasonally dry tropical forest tree diversity survey

	Total samples	Individuals identified (%)	Mean sample size	Families	Genera	Species	Possible new species
Honduras	22	97	40.3	56	139	194	0
Oaxaca	21	91	38.4	63	160	252	4
Total	43	94	39.3	70	210	375	4

of degree-squares from which botanical samples had been collected (x in Table 2). These areas were then divided by the mean green star area (y in Table 2) so that each category was weighted relative to a value of one for the *green stars*. The weights were then inverted, thus giving higher values to 'rarer' species, and rounded to the nearest integer ($1/y$ in Table 2). Finally the green star weighting was arbitrarily reduced from one to zero to reflect the lack of conservation concern we wished to give to these species.

2.5. Calculation of genetic heat indices

Using the weights calculated in Table 2, the mean score for each sample was calculated as a *Genetic Heat Index* (GHI, Hawthorne, 1996) for each sample using the formula:

$$\mathrm{GHI} = \frac{\begin{aligned}&[(\text{No black star spp.} \times 32)\\&+(\text{No of gold spp.} \times 12)\\&+(\text{No of blue star spp.} \times 5)] \times 100\end{aligned}}{N}$$

GHIs reflect the proportion of restricted range species in a sample. Because the denominator, N, is all species in the sample, an average is produced that allows comparison of samples with different numbers of species. Ideally N should be reasonably large (>30) to ensure GHIs are not overly sensitive to the inclusion or loss of single black or gold star species.

3. Results

3.1. Floristic description of Honduran and Oaxacan forest samples

Table 3 shows the Oaxacan samples to be more diverse than the Honduran samples at the level of family, genus and species.

Amongst the Honduran samples the most speciose families were Mimosaceae with 16 species in nine genera, Papilionaceae with 11 species in eight genera, Euphorbiaceae with 11 species in eight genera, Caesalpiniaceae with 10 species in five genera and Rubiaceae with 10 species in nine genera. The most speciose genera encountered were *Ficus* (Moraceae) and *Cordia* (Boraginaceae) with five species each and *Annona* (Annonaceae), *Senna* (Caesalpiniaceae), *Solanum* (Solanaceae) and *Trichilia* (Meliaceae) each with four species.

The most speciose familes encountered in Oaxaca were Mimosaceae with 25 species in 13 genera, Papilionaceae with 24 species in 15 genera, Euphorbiaceae with 19 species in nine genera, Caesalpiniaceae with 15 species in five genera and Rubiaceae with 10 species in nine genera. The most speciose genera encountered were *Bursera* (Burseraceae) and *Caesalpinia* (Caesalpiniaceae) with eight species each, *Acacia* (Mimosaceae), *Croton* (Euphorbiaceae) and *Lonchocarpus* (Papilionaceae) with seven species each, *Ficus* with six species, *Cordia* with five species and *Capparis* (Capparidaceae) and *Jatropha* (Euphorbiaceae) with four species each.

These results are broadly similar to the patterns of tree diversity described by Gentry (1995) for other areas of neotropical dry forest. In comparison with paleotropical dry forests, the dominance of the Leguminosae appears to be pantropical, however, in Central African Republic and Gabon there is evidence that the Apocynaceae make a greater contribution to diversity than in the neotropics, (Phillips and Miller, 2002) and Sussman and Rakotozafy (1994) report dominance of Tiliaceae in Madagascar.

Fig. 2 shows the relationship between Honduran and Oaxacan samples. The lower between-sample diversity of the Honduran samples is reflected in the greater clustering of those samples.

Two Way Indicator Species Analysis (TWINSPAN) of the samples reveals species characteristic of both the Honduran and Oaxacan samples to be (in descending order of occurrence) *Bursera simarouba* (L.) Sarg. Burseraceae, *Cochlospermum vitifolium* (Willd.) Spreng. (Cochlospermaceae), *Jacquinia macrocarpa* Cav. (Theophrastaceae), *Plumeria rubra* L. (Apocynaceae), *Spondias purpurea* L. (Anacardiaceae), *Thevetia ovata* (Cav.) A.DC. (Apocynaceae) and *Tabebuia rosea* (Bertol.) DC. (Bignoniaceae).

Species commonly encountered in the Honduran samples but rarely or never in the Oaxacan samples, i.e. indicative species of the Honduran samples, include *Gyrocarpus americanus* Jacq. (Hernandiaceae), *Trichilia americana*, (Sessé & Moc.) T.D.Penn. and *Swietenia humilis* Zucc. (Meliaceae), *Lonchocarpus minimiflorus*

Donn.Sm., *Bunchosia odorata* (Jacq.) Kunth (Malpighiaceae), *Alvaradoa amorphoides* Liebm. (Simaroubaceae), *Guazuma ulmifolia* Lam. (Sterculiaceae), *Coutarea hexandra* (Jacq.) K.Schum. (Rubiaceae) and *Albizia niopoides* (Benth.) Burkart var. *niopoides* (Mimosaceae).

Species indicative of the Oaxacan samples include *Amphipterygium adstringens* (Schltdl.) Standl. (Anacardiaceae), *Guaiacum coulteri* A.Gray (Zygophyllaceae), *Forchhammeria pallida* Liebm. and *Crataeva tapia* L. (both Capparidaceae), *Bursera excelsa* (Kunth) Engl. (Burseraceae), *Jacaratia mexicana* A.DC. (Caricaceae), *Apoplanesia paniculata* C.Presl (Papilionaceae) and *Comocladia engleriana* Loes. (Anacardiaceae).

3.2. Conservation importance of Honduran and Oaxacan forest samples

Only those records identified to species, plus those unidentified records which were considered to be possible undescribed species (and therefore of considerable potential conservation importance and thus categorised as black stars), are included in the calculation of GHIs.

Table 4 shows the genetic heat indices of the forest samples. There is clear disparity in the highest scores found in the two regions, with the Oaxacan forests, on this measure, containing areas of far greater potential for the conservation of threatened woody diversity than the Honduran samples. This is a direct result of the disparity in the numbers of black, gold, and blue stars species that were found in the two sets of samples. Tree and shrub species of limited distribution are very uncommon in the samples from southern Honduras (see Appendix).

3.3. Between-sample diversity of forests and forest fallows in Oaxaca

The second stage of the analysis presented here considers the potential for landscape elements other than mature forest, e.g. forest fallows, to contribute to woody diversity conservation. Given the clear difference in GHI scores obtained for Honduran and Oaxacan forest samples, Oaxacan fallows were the subject of this additional sampling carried out in the two communities described.

In La Jabalina, a community which contains significant fragments of mature forest, 10 of these fragments (three semideciduous, and seven deciduous forests) were sampled for comparison with samples from six forest fallows, all considered to be of deciduous forest origin. On the other hand, El Limón is a community with extensive areas of forest fallow and little or no forest. From this community seven forest fallows, also assumed to be of deciduous forest origin, were sampled for comparison with the three samples taken from the neighbouring Cerro Guiengola included in the forest samples described above. The total number of samples analysed here is therefore 26, in which 92% of individuals where identified to species. Sample size was relaxed here to accommodate the fewer species present in forest fallows of small size. Thus a per sample average of 37.8 identified species were entered into the analysis. These additional samples contributed a further 72 species to the 252 species identified in the forest samples (Table 3). The floristic relationships between these samples are shown in Fig. 3.

As in Fig. 2, Fig. 3 reveals the samples from semideciduous forest (in this case only from La Jabalina) to

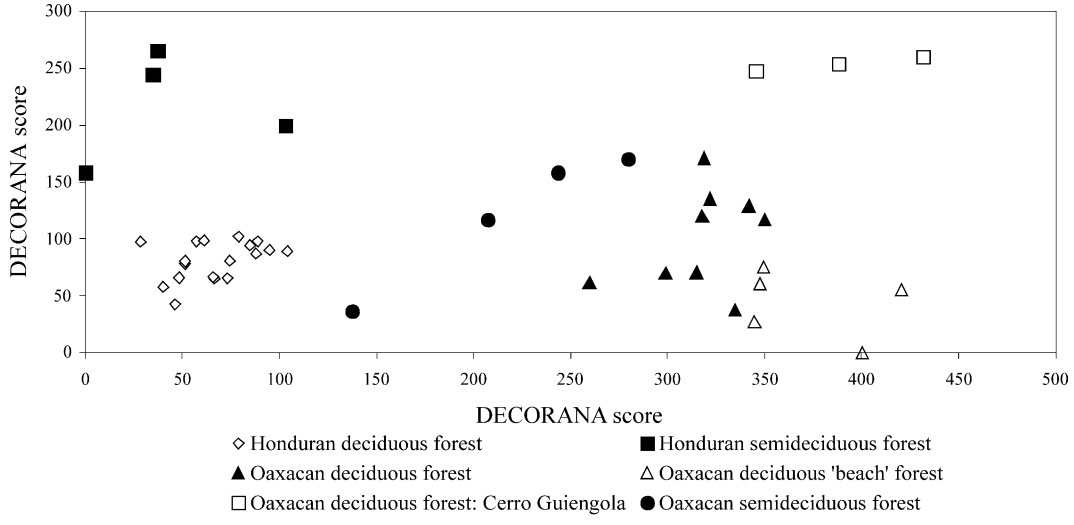

Fig. 2. Detrended correspondence analysis (unweighted) of Honduran and Oaxacan seasonal forest tree and shrub diversity.

Table 4
Forest quality as measured by genetic heat indices (descending order) of seasonally dry tropical forests sampled in southern Honduras and coastal Oaxaca, Mexico

Location	Type	GHI
Mexican forests		
Cerro Guiengola, Tehuantepec	Mature deciduous forest	358
Puente Coralito	Mature deciduous forest	333
Playa Entrega, Huatulco	Deciduous forest bordering beach	277
Cerro Guiengola, Tehuantepec	Mature deciduous forest	263
Cerro Huatulco, Huatulco	Mature semideciduous forest	246
Playa Entrega, Huatulco	Deciduous forest bordering beach	232
San Isidro Chacalapa[a]	Secondary deciduous forest	226
Tehueca, Pochutla	Hurricane damaged deciduous forest	202
Zimatán[a]	Mature deciduous forest	168
Cerro Huatulco, Huatulco	Mature semideciduous forest	150
Zimatán[a]	Mature deciduous forest	138
Playa San Agustín, Huatulco	Deciduous forest bordering beach	134
Cerro Guiengola, Tehuantepec	Secondary deciduous forest	132
Rio Ayuta[a]	Mature deciduous forest	131
Zimatán[a]	Mature deciduous forest	93
La Cañada, Tututepec	Secondary semideciduous forest	93
Zimatán[a]	Mature deciduous forest	73
Playa El Organo, Huatulco	Deciduous forest bordering beach	61
Playa Chachacual, Huatulco	Deciduous forest bordering beach	45
San Pedro, Tututepec	Secondary semideciduous forest	36
Puente Aguacate, Pochutla	Hurricane damaged semideciduous forest	14
Honduran Forests		
Cerro Calaire, Choluteca	Secondary deciduous forest	77
Los Hermanos, Choluteca	Secondary deciduous forest	54
Cerro Las Tablas, Choluteca	Secondary deciduous forest	50
Cerro Zurquillas, Choluteca	Secondary semideciduous forest	41
Cerro Mapachin, Valle	Secondary deciduous forest	40
Cerro El Tambor, Choluteca	Secondary deciduous forest	38
Cerro Las Tablas, Choluteca	Secondary deciduous forest	33
Cerro Las Tablas, Choluteca	Secondary deciduous forest	30
Cerro Las Tablas, Choluteca	Secondary deciduous forest	30
Cerro Guanacaure, Choluteca	Secondary deciduous forest	27
Cerro El Avion, Valle	Secondary deciduous forest	26
Cerro Las Tablas, Choluteca	Secondary deciduous forest	25
El Chaparal, Valle	Secondary deciduous forest	13
Pavana, Choluteca	Secondary deciduous forest	13
Pavana, Choluteca	Secondary deciduous forest	13
El Corpus, Choulteca	Secondary semideciduous forest	12
El Ricon Orocuina, Choluteca	Secondary deciduous forest	11
Cerro El Avioncito, Valle	Secondary deciduous forest	0
El Chaparal, Valle	Secondary deciduous forest	0
Cerro Palin, Valle	Secondary deciduous forest	0
Pavana, Choluteca	Secondary deciduous forest	0
Cerro Guanacaure, Choluteca	Secondary semideciduous forest	0

[a] Samples within the Zimatán–Ayuta watersheds.

be the most heterogeneous group in the sample. TWINSPAN does not distinguish these samples as a group, it does however select *Astronium graveolens* Jacq. (Anacardiaceae), *Chrysophyllum mexicanum* Brandegee ex Standl. (Sapotaceae), *Trichilia hirta* L. (Meliaceae) and *Andira inermis* (Wright) Kunth (Papilionaceae) as indicators of the two samples with the lowest *y* axis score, whilst the latter two of these species are also present in the third semideciduous forest sample.

The intimate mixing of the fallow and deciduous forest samples shown in Fig. 3, implies that these land-uses share a large proportion of their species and therefore that forest fallows may have a role in forest tree diversity conservation. The following species identified as conservation priorities (Appendix) were found both in forest fallows and deciduous forest fragments in La Jabalina: *Achatocarpus oaxacanus* H.Walter (Achatocarpaceae), *Brongniartia bracteolata* Micheli and

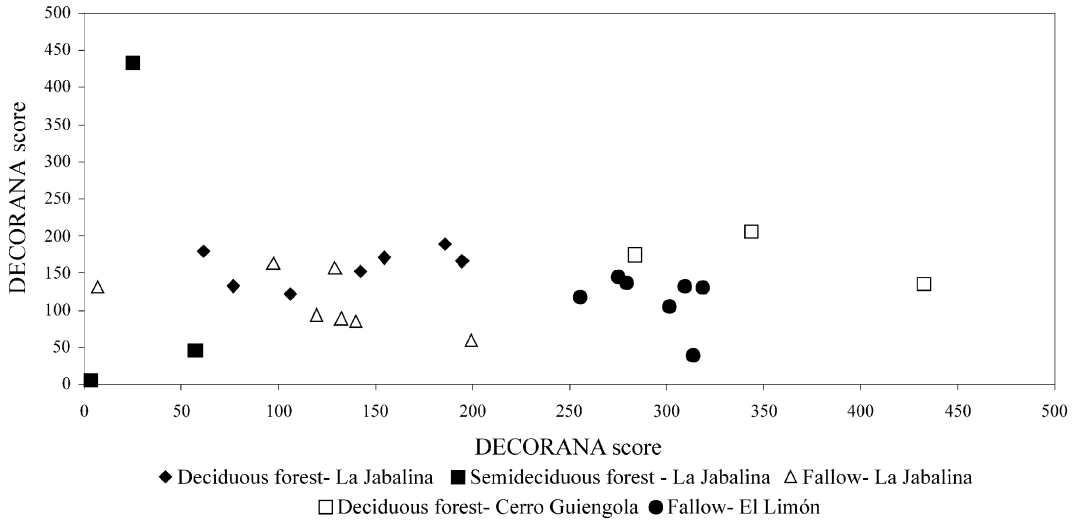

Fig. 3. Detrended correspondence analysis (unweighted) of seasonal forest tree and shrub diversity in two agrarian communities in Oaxaca, Mexico.

Caesalpinia hughesii, G.P.Lewis (both Caesalpiniaceae), *Croton septemnervius* McVaugh (Euphorbiaceae), *Bucida macrostachya* Standl. (Combretaceae) and *Recchia mexicana* Moc. & Sessé ex DC. (Simaroubaceae).

The principal division made by TWINSPAN is between the samples from La Jabalina and those of Cerro Guiengola and El Limón combined (see also Fig. 2). Species which show a preference for the La Jabalina samples include *Ceiba aesculifolia* (Kunth) Britton & Baker f. (Bombacaceae), *Achatocarpus mexicanus*, *Cordia elaeagnoides* A.DC. and *Cordia alliodora* (Ruiz & Pav.) Oken (Boraginaceae), *Crataeva tapia* L. (Capparidaceae), *Spondias purpurea* (Anacardiaceae) and *Calycophyllum candidissimun* (Vahl) DC. (Rubiaceae).

Species which are indicative of Cerro Guiengola and the El Limón fallows include *Gyrocarpus mocinnoi* Espejo (Hernandiaceae), *Bursera excelsa* (Kunth) Engl. and *Bursera schlechtendalii* Engl. (Burseraceae), *Randia thurberi* S.Watson (Rubiaceae) and *Thouinia serrata* Radlk. (Sapindaceae).

The relationship between the forest fallows of El Limón and the forests of Cerro Guiengola is less intimate but there is some overlap of species, including the conservation priorities, *G. moccinoi*, *Jatropha sympetala* Standl. & Blake and *Jatropha alamani* Muell. Arg. (Euphorbiaceae), *Havardia campylacanthus* (L.Rico & M.Sousa) Barneby & J.W.Grimes (Mimosaceae) and *Bucida macrostachya*. It should, however, be noted that the sample from Cerro Guiengola which has the lowest *x* axis score and that is therefore most like that of the fallows of El Limón is the secondary forest sample listed in Table 3. Forest disturbance may therefore being having a homogenising effect on vegetation in this area (McKinney and Lockwood, 1999).

3.4. Conservation importance of forest fallows

Table 5 shows that the forest fragments of La Jabalina have comparable conservation importance to the forests of the neighbouring Zimatán–Ayuta watersheds. It also clearly indicates that the best forest samples as measured by GHIs are better than the best forest fallows. None the less, four of the fallows samples score 100 or more which compares well with many of the forests listed in Table 4, and five score higher than *any* of the Honduran forests sampled. Furthermore, as noted above, there are several priority species common to both the fallow areas and to the forest with which they are compared. It is interesting to note that there appears to be little relationship between the estimated age of the sample, which was determined by asking the community member who controlled the fallow, and the GHI. It appears that in this community with access to ample land and correspondingly large areas of fallow, the restricted range species which contribute to high GHIs can establish quickly after a field is allowed to go to fallow, either from stumps, the seed bank or from the arrival of propagules.

4. Discussion

4.1. Floristics

The greater tree and shrub diversity of the Oaxacan SDTF compared to that of southern Honduras accords with Gentry's (1988, 1995) conclusions that tropical dry forests, in contrast to wet forests, may be more diverse at higher latitudes than lower latitudes. The state of Oaxaca is considered to be of outstanding biological diversity even by the standards of megadiverse Mexico (Mittermeier and Mittermeier, 1992), so a naturally

Table 5
Forest quality as measured by genetic heat indices (GHIs) of vegetation samples in two agrarian communities in coastal Oaxaca, Mexico

Land-use type	Vegetation type	GHI
Forests 'La Jabalina'	Mature lightly intervened deciduous forest	240
	Mature deciduous forest intervened by humans and hurricane	197
	Mature lightly intervened deciduous forest	193
	Mature lightly intervened deciduous forest	161
	Mature semideciduous forest with minimal human intervention	136
	Mature deciduous forest with minimal human intervention	94
	Mature semideciduous forest with minimal human intervention	33
	Mature lightly intervened deciduous forest	28
	Mature semideciduous forest with hurricane damage	25
	Secondary deciduous forest	13
Forest fallows, 'La Jabalina'	Deciduous forest regeneration, 7 years old	183
	Deciduous forest regeneration, 15 years old	74
	Deciduous forest regeneration, 2 years old	73
	Deciduous forest regeneration, 33 years old	33
	Deciduous forest regeneration, 6 years old	29
	Deciduous forest regeneration, 7 years old	17
Deciduous forest Cerro Guiengola	Mature deciduous forest	358
	Mature deciduous forest	307
	Secondary deciduous forest	132
Forest fallows, El Limón	Deciduous forest regeneration, >20 years old	228
	Deciduous forest regeneration, 4 years old	178
	Deciduous forest regeneration, 15 years old	100
	Deciduous forest regeneration, >15 years old	97
	Deciduous forest regeneration, >15 years old	71
	Deciduous forest regeneration, 2 years old	61
	Deciduous forest regeneration, >15 years old	45

greater diversity in Oaxaca might be expected. In relation to the forests in this survey this may be due in part to a greater variation in habitats in Oaxaca. No forests of equivalent topology or geology to those of Cerro Guiengola were found in southern Honduras, neither were significant areas of dry forest found on dunes and rocky out-crops around sandy beaches. Both these forest types clearly increase between-sample diversity in Oaxaca (Fig. 1).

However a second factor, successional status, may be of equal if not greater importance in explaining the differences between Honduran and Oaxacan samples. Visual inspection of the forests sampled in Honduras, and consideration of aerial photographs, lead the field teams involved in this work to conclude that all the dry forest patches of southern Honduras were of relatively recent secondary origin, probably of the order of a few decades at most. This does not discount the possibility that some individual trees may be remnants of more mature vegetation. In coastal Oaxaca much more mature forest (we avoid the term primary as none of the forests could confidently have been described as completely undisturbed) are still to be found and the emphasis on the sampling discussed here was on the larger, and therefore possibly more mature forests of the region. The overall greater species count obtained for coastal Oaxaca (Table 3) may well therefore at least in part be due to the presence of later successional species in Oaxaca. Certainly successional status may explain the surprising result that species such as *Guazuma ulmifolia* and *Swietenia humilis* are indicative of the Honduran samples alone. Even though they are well known and common in coastal Oaxaca, they are pioneer type species not often encountered in mature forest. The preference of several other species for the Honduran samples also disguises the fact that they are commonly encountered species in Oaxaca outside of mature forest, and include *Luehea candida* (Moc. & Sessé ex DC.) M. Mart. (Tiliaceae), *Acacia hindsii*, Benth. and *Acacia collinsii* Saff. (Mimosaceae), *Gliricidia sepium* and *Trema micrantha*. (L.) Blume (Ulmaceae). However, in the case of *Swietenia humilis*, its rarity in mature forest in Oaxaca may also be, at least partially, a result of selective logging. There are however various species amongst those commonly encountered in the Oaxacan samples that may also be early successional species. These include the ubiquitous *Cochlospermum vitifolium* and *Tabebuia rosea*, the former of which appears particularly resistant to hurricane damage (Gordon, pers. obs.), and amongst those exclusive to the Oaxacan samples *Jacaratia mexicana*, *Apoplanesia paniculata* and *Comocladia engleriana*. Thus the distinction between the 'mature' Oaxacan samples and the secondary Honduran ones is not absolute, but a matter of degree.

The importance of anthropogenic disturbance and successional status in explaining regional patterns of

diversity in neotropical SDTF may also go some way to explaining the latitudinal gradient in diversity discussed by Gentry (1988, 1995). Two of the data sets he used are from Chamela in the state of Jalisco, Mexico and Guanacaste, Costa Rica. Rather than be an effect relating to latitude per se, the higher diversity levels in the former may reflect the more mature status of this forest (Gordon, pers. obs.) compared to the latter which is dominated by secondary successions established on old, fire maintained cattle pasture (Janzen, 1986). Gillespie et al. (2000) in discussing Nicaraguan and Costa Rican dry forests note that the least diverse of the forests they surveyed was also the most fire affected. However Trejo and Dirzo (2002) also offer compelling evidence for a relationship between potential evapotranspiration and floristic diversity in Mexican SDTF, and we do not discount that this may also be a factor.

4.2. Conservation importance

Given the clear contrast between the GHI scores of the Honduran forest samples and those of Oaxaca, we focus our discussion on the potential role of these Oaxacan forests in Mesoamerican SDTF conservation. However, we do so acknowledging the limitations outlined by Possingham et al. (2002) of the use of rare species lists in conservation planning, and we emphasise three important caveats. First we stress that our analysis, like so many biodiversity assessments, is partial, limited as it is to tree and shrub diversity. The degree to which these conclusions hold for other groups of plants and for animals remains untested, although Gillespie and Walter (2001) provide evidence for species richness correlations between birds and woody vegetation elsewhere in Central American SDTF. The second is that we offer no analysis of other areas of SDTF in Honduras, which include several dry interior valleys where rarity and endemism might be greater. The third is to emphasise that this analysis takes a global approach to determining the importance of diversity, based as it is on the proportion of species in a sample that are considered to be in some danger of global extinction. A more locally orientated approach is likely to take a different but equally valid view of a species' importance, the uses of each species probably being a more important consideration than the sizes of their distributions (Gordon et al., in press). Some aspects of the conservation of tree and shrub diversity in southern Honduras relating to the surveys discussed here are further discussed in Barrance et al. (in press), Boshier et al. (in press) and Gordon et al. (2003).

From the Oaxacan forest samples we identify four areas which should be given particular consideration for conservation (Fig. 1 and Tables 4 and 5). The deciduous forest of Cerro Guiengola; the deciduous forests and fallows of La Jabalina and the Zimatán-Ayuta watersheds which form several of the 'Oaxacan Deciduous Forest' samples of Fig. 2; the semideciduous forest of Cerro Huatulco which are the two 'Oaxacan Semideciduous Forest' samples nearest the centre of Fig. 2; and the deciduous 'beach' forests on the dunes and rocky outcrops of the Oaxacan coastline around the Bahías de Huatulco.

Both Cerro Guiengola and Cerro Huatulco are protected by their steep topography (*cerro* = hill). Cerro Guiengola is further protected as an archaeological site, as it contains a precolombian ruin. It is currently little visited by tourists and it cannot be considered in immediate danger, however, should often suggested plans for its more complete development as a tourist site become reality, conservation agencies will need to ensure this does not compromise its outstanding importance for biodiversity conservation. It is an isolated hill top forest and the degree to which other land-uses, especially forest fallows in neighbouring communities such as those of El Limón, can contribute to increasing the effective area of forest cover under some form of conservation management may prove important in the long-term maintenance of its diversity. The analysis presented here suggests that, at least in terms of their species content, such forest fallows could indeed have such a role.

The importance of maintaining forest cover on Cerro Huatulco is not locally in doubt as it protects the water supply of the town of Santa María de Huatulco. It has the status of a Communally Managed Protected Area and has attracted the interest of local conservation organisations. Its immediate future as a site of important woody diversity therefore appears relatively secure.

Beach-based tourism development along this coast is already considerable and is increasing. The forests around several sandy bays along this coast are at least nominally protected by their inclusion in the approximately 6 000 ha of forest that forms part of the Parque Nacional Huatulco (Escamirosa Tinoco and Hernández, 2000). This protected area was created as a by-product of the expropriation of land required for the development of the relatively new Bahías de Huatulco tourist resort. However the rocky slopes around Playa Entrega (*playa* = beach) from which samples with the highest GHI scores come is not within this protected area, and even those within it already receive considerable numbers of visitors and are likely to receive more as tourism grows. At the very least, therefore, monitoring of this vegetation type will be important, as will be the identification and protection of other forested bays along the coast that are more isolated from sites of mass tourism.

The largest expanse of SDTF in the coastal region is formed by the forests and fallows of La Jabalina and in the Zimatán-Ayuta watersheds. This area includes the 'Copalita' area sampled by Trejo and Dirzo (2002)

which they identify as one of Mexico's outstandingly diverse SDTF areas. Furthermore, in contrast to the 'moderate to steep slopes and rocky outcrops' on which most of the forests they sampled were found, this area also includes significant amounts of forest cover on low lying sandy soils, especially around La Jabalina. Communal forms of land ownership are the norm here, and it seems likely that the restrictions on the number of people who can use communal land has allowed considerable areas to be maintained under mature forest and long-cycle forest fallows. Furthermore, social capital in the form of communal management structures results in a high degree of awareness of the collective importance of natural resources and facilitates their protection, as is evidenced by the creation of a Communally Managed Protected Area in part of this forest around La Jabalina.

As we have argued, forest fallow can also make a contribution to the conservation value of the area and so it would seem that current land-use practices have much to offer conservation initiatives. Indeed we advocate an approach to forest conservation in the region which integrates the cycle of forest fallow regeneration into conservation planning. This positive view of communal management contrasts with the more negative conclusions drawn by Stedman-Edwards (2000) on the effects of communal land tenure in the SDTF of the Calakmul Biospehere reserve in Campeche, Mexico.

Recent national law changes, however, threaten the stability of the *ejido* system, one of the forms of communal tenure common in the area. It is now legally possible for a community to privatise land ownership, potentially allowing increased pressure on available land in coastal Oaxaca through division and sale of land to immigrants. As yet there is no evidence that this option has been taken up with any enthusiasm by the communities of coastal Oaxaca.

5. Conclusions

For the conservation of restricted range tree and shrub diversity, coastal Oaxaca would represent a far better investment for those organisations promoting SDTF conservation than would southern Honduras. Fortunately, several international agencies in collaboration with many local non-government organisations are already active in conservation in this part of Mexico. We encourage further funding of these local organisations. We conclude that forest fallows and forest fragments (Janzen, 1988b) can act as an analogue of mature, larger forest areas, both in terms of species content and to a lesser, but significant, extent in their content of restricted range species. Thus continued conservation efforts in the region should work with, rather than against, traditional systems of social organisation and landscape management. This insight would not have been gained if we had not considered within-landscape patterns of diversity. Conservation planning should therefore go beyond consideration of only the most extensive and 'pristine' (Denevan, 1992) elements of the landscape and adopt an agroecosystem focus (Vandemeer and Perfecto, 1997). Indeed some Oaxacan organisations have taken this approach for some time.

We conclude that further efforts to identify suitable sites for SDTF tree diversity conservation should begin with areas of relatively extensive and under-explored mature forest, i.e. those similar to coastal Oaxaca, still found along Mexico's Pacific coast. In this recommendation we concur with Ceballos et al. (1998) who consider priorities amongst Mexico's mammalian fauna. However, such surveying, whether it be of Mesoamerican SDTF or any other forest type, should not discount a priori other tree containing elements in the landscape.

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APPENDIX ON NEXT PAGE

Appendix. Species conservation priorities identified in the seasonally dry tropical forests of southern Honduras and coastal Oaxaca, Mexico

Honduran species in bold, *Rondeletia deemii* being the only priority species to appear in both sets of samples. Family level nomenclature follows that of Mabberley (1997), except that for brevity Caesalpinioideae, Mimosoideae and Papilionoideae are treated as separate families. Those species marked * are not primarily limited to SDTF forests.

Family	Species	Summarised distribution
Black star species		
Achatocarpaceae	*Achatocarpus oaxacanus* Standl.	Oaxacan dry forest endemic
Caesalpiniaceae	*Caesalpinia coccinea* G.P.Lewis & J.L.Contr.	Oaxacan dry forest endemic
Compositae	*Trixis silvatica* B.L.Rob. & Greenm.	Oaxacan dry forest endemic
Euphorbiaceae	*Jatropha alamani* Muell. Arg.	Oaxacan dry forest endemic
Euphorbiaceae	*Jatropha sympetala* Standl. & Blake	Oaxacan dry forest endemic
Euphorbiaceae	*Manihot oaxacana* D.J.Rogers & Appan	Oaxacan dry forest endemic
Malpighiaceae	*Bunchosia discolor* Turcz. ex Char.	Oaxacan dry forest endemic
Mimosaceae	*Mimosa albida* Humb. & Bonpl. ex Willd. var. *pochutlensis* R.Grether	Oaxacan dry forest endemic
Mimosaceae	*Zapoteca tehuana* H.M.Hern.	Oaxacan dry forest endemic
Simaroubaceae	*Castela retusa* Liebm.	Oaxacan dry forest endemic
Sterculiaceae	*Waltheria conzatii* Standl.	Oaxacan dry forest endemic
Gold star species		
Annonaceae	*Sapranthus foetidus* (Rose) Saff.	Jalisco, Guerrero, Oaxaca
Boraginaceae	*Bourreria purpusii* Brandgee	Jalisco, Oaxaca
Caesalpiniaceae	*Brongnartia bracteolata* Micheli	Oaxaca, Chiapas
Caesalpiniaceae	*Caesalpinia hughesii* G.P.Lewis	Oaxaca, Guerrero, Colima
Capparidaceae	*Capparis angustifolia* Kunth	Michoacan Guerrero, Oaxaca
Capparidaceae	*Forchhammeria lanceolata* Standl.	Oaxaca, Guerrero
Combretaceae	*Bucida wigginsiana* Miranda	Guerrero, Oaxaca
Compositae	*Trixis pterocaulis* B.L.Rob. & Greenm.	Sinaloa, Jalisco, Colima, Oaxaca
Malvaceae	*Hibiscus kochii* Fryxell	Guerrero, Oaxaca
Mimosaceae	***Leucaena salvadorensis* Standl.**	**El Salvador, Nicaragua, Honduras**
Myrtaceae	***Eugenia hondurensis* Ant. Molina**	**Oaxaca? Honduras, Nicaragua**
Myrtaceae	*Eugenia salamensis* Donn.Sm. var. *rensoniana* (Standl.) McVaugh	Oaxaca, Guatemala, Costa Rica
Nyctaginaceae	***Grajalesia fasciculata* (Standl.) Miranda**	**Oaxaca? Guatemala, El Salvador, Honduras, Nicaragua**
Papilionaceae	*Lonchocarpus emarginatus* Pittier	Oaxaca, Chiapas
Papilionaceae	*Lonchocarpus longipedicellatus* Pittier	Jalisco, Guerrero, Oaxaca
Rubiaceae	***Guettarda deamii* Standl.**	**Guatemala, El Salvador, Honduras, Nicaragua**
Rubiaceae	*Guettarda galeottii* Standl.	Sinaloa, Nayarit, Oaxaca
Rubiaceae	*Randia cinerea* (Fernald) Standl.	Oaxaca, Guerrero
Simaroubaceae	*Recchia mexicana* Moc. & Sessé	Oaxaca, Jalisco
Sterculiaceae	*Physodium oaxacanum* Dorr & Barnett	Oaxaca, Chiapas
Blue star species		
Achatocarpaceae	*Achatocarpus mexicanus* H.Walter	Oaxaca, Chiapas*
Amaranthaceae	*Lagrezia monosperma* (Rose) Standl.	Jalisco, Michoacan, Colima, Guerrero, Oaxaca

(continued on next page)

Appendix (*continued*)

Family	Species	Summarised distribution
Blue star species		
Anacardiaceae	***Actinocheitia filicina* (DC.) F.A. Barkley**	**Guerrero, Oaxaca, Chiapas, Honduras***
Burseaceae	*Bursera instabilis* McVaugh & Rzed.	Nayarit, Jalisco, Michoacan, Colima, Guerrero, Oaxaca
Caesalpiniaceae	*Caesalpinia mollis* (Kunth) Spreng.	Oaxaca, Chapas, Yucatán*
Combretaceae	*Bucida macrostachya* Standl.	Oaxaca, Chiapas, Guatemala, Honduras, Nicaragua
Compositae	*Verbesina oaxacana* DC.	Oaxaca*
Euphorbiaceae	*Croton axillaris* Muell. Arg.	Oaxaca, Chiapas, Tamaulipas, Guatemala, Nicaragua
Euphorbiaceae	*Croton ramillatus* Croizat	Guerrero, Oaxaca, Veracruz*
Euphorbiaceae	*Croton septemnervius* McVaugh	Jalisco, Guerrero, Oaxaca*
Flacourtiaceae	***Casearia williamsiana* Sleumer**	**Honduras***
Flacourtiaceae	*Samyda mexicana* Rose	Jalisco, Guerrero, Oaxaca, Veracruz*
Hernandiaceae	*Gyrocarpus mocinnoi* Espejo	Guerrero, Chiapas, Oaxaca, Puebla, Guatemala
Labiatae	*Hyptis tomentosa* Poit.	Oaxaca Chiapas Veracruz*
Lauraceae	***Persea caerulea* (Ruiz & Pav.) Mez**	**EL Salvador, Honduras, Nicaragua, Costa Rica, Panama**
Malvaceae	*Abutilon grandidentatum* Fryxel.	Oaxaca, Chiapas*
Mimosaceae	*Havardia campylacanthus* (L.Rico & M.Sousa) Barneby & J.W.Grimes	Michoacan, Guerrero, Oaxaca, Nicaragua, Honduras*
Mimosaceae	*Mimosa eurycarpa* B.L.Rob.	Michoacan, Colima, Oaxaca*
Nyctaginaceae	*Torrubia macrocarpa* Miranda	Jalisco, Michoacan, Oaxaca, Puebla, Morelos
Papilionaceae	*Lonchocarpus constrictus* Pittier	Jalisco, Michoacan, Colima, Guerrero, Oaxaca
Papilionaceae	*Indigofera platycarpa* Rose	Guerrero, Oaxaca, Puebla, Morelos*
Rubiaceae	*Randia nelsonii* Greenm.	Sinaloa, Michoacan, Oaxaca, Veracruz*
Rubiaceae	***Randia pleiomeris* Standl.**	**Guatemala, EL Salvador, Honduras***
Rubiaceae	***Rondeletia deamii* (Donn.Sm.) Standl.**	**Oaxaca, Guatemala, Honduras, Nicaragua***
Tiliaceae	*Heliocarpus occidentalis* Rose	Guerrero, Oaxaca*
Trigoniaceae	***Trigonia rugosa* Benth.**	**Guatemala, EL Salvador, Honduras, Nicaragua***

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BIODIVERSITY CONSERVATION *in* COSTA RICA

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CHAPTER 16

Prospects for *Circa Situm* Tree Conservation in Mesoamerican Dry-Forest Agro-Ecosystems

David H. Boshier, James E. Gordon, and Adrian J. Barrance

DRY FOREST ONCE STRETCHED almost continuously along the Mesoamerican (Central American/Mexican) Pacific coast, from Sonora in Mexico to Guanacaste in Costa Rica (area of 550,000 km^2). Conditions suitable for dry forest also exist on the Yucatán Peninsula, the coast of the Mexican states of Puebla and Tamaulipas, with significant inland areas in dry valleys (e.g., Motagua Valley, Guatemala) throughout the region (see Graham and Dilcher 1995 and Murphy and Lugo 1995 for the distribution and origins of this forest type). Human preference for the seasonally dry tropical environment (Murphy and Lugo 1995) and the ease of clearing its vegetation have, however, led to the destruction and fragmentation of much of its forest. Janzen (1988: 130) estimated that less than 2 percent of the original forest is in a state "sufficiently intact to attract the attention of the traditional conservationist," with only 0.09 percent having official reserve status. Only on the Pacific Mexican coast are there significant areas of mature, possibly primary, dry forest. Even in these areas it is rare to find a forest with no evidence of occasional timber and firewood extraction, extensive livestock browsing, or hunting. In Central America the dry-forest zone is reduced to a patchwork of various types of agricultural land and small forests of secondary origin. Unregulated selective felling of economically important tree species continues, resulting in the commercial extinction of timber species in some areas (e.g., *Astronium graveolens* Jacq., *Guaiacum sanctum* L.). Reserve selection is often opportunistic, determined more by political, social, and economic constraints than by optimal biological criteria. Consequently the location of reserves may bias floristic composition (at species and gene pool levels), limiting their overall value for biodiversity conservation (Ledig 1988).

Any conservation initiative requires consideration of the extent and value of and threat to the resource to be targeted. Tropical dry forests are species-rich in comparison with most of the world's forest types (Gentry 1995). Biodiversity can, however, be measured at a variety of levels, and species numbers alone are an insufficient and poor measure of the conservation importance of any ecosystem. Consideration must also be given to the biota's uniqueness, as well as the importance of interactions with other ecosystems. At the species level, Mesoamerican dry forests contain a woody flora that is distinct from that of Mesoamerican wet forests (Gentry 1995). Even for tree species that occur in both wet and dry forests, the dry-forest populations have typically been shown to be genetically distinct from wet forest populations (e.g., *Cordia alliodora* [R. et P.] Oken, Chase et al. 1995; *Cedrela odorata* L., Gillies et al. 1997). Mesoamerican dry forests are also host, depending on the season, to many migratory species, including species from the wet tropics (chapters 7 and 8), such that its conservation is important in protecting more than just its own biota.

Interest in the conservation of these species and their habitat is not confined to biologists. Mesoamerican dry forests are the natural habitat of a disproportionately high number of species commonly used in tropical agriculture and forestry for a variety of goods and services, such as *Gliricidia sepium* (Jacq.) Steudel, *Leucaena* spp., *Prosopis juliflora* (Swartz) D.C., and *Samanea saman* (Jacq.) Merrill. These species are now propagated over much broader climatic and geographical ranges than their natural distributions and have considerable socioeconomic importance (e.g., Stewart et al. 1992). Continued use and improvement of such species depend to some extent on the maintenance of genetic variation within and between natural and semi-natural populations.

OPTIONS FOR CONSERVATION

IN SITU CONSERVATION

Conservation faces a problem. Mesoamerican dry forest is diverse and distinctive, containing many socioeconomically important species; however, existing reserves cover a very small fraction of the original forest, and few intact dry forests are left to conserve. The degree to which *in situ* reserves are appropriate for conservation depends on a variety of factors, such as forest size, the extent of fragmentation, and the prevailing socioeconomic context. Those forests that do remain are usually small (e.g., 1–500 ha), below the size that might be considered viable, and highly intervened, such that the ideal of maintaining a single large reserve is often irrelevant (as in the "single large or several small" debate; see Soulé 1987). Consideration must therefore be given to the biological and social feasibility of managing networks of small patches within the current land-use mosaic. Conservation initiatives for dry forest must examine approaches that depart from the traditional *in situ* conservation paradigm, involving protected "wilderness areas," and focus as well on ways in which the species of an already highly altered forest type can be conserved.

ECOLOGICAL RESTORATION

Ecological restoration has been proposed as a tool to redress the inadequacies of current reserves (e.g., Janzen 1986a), and extensive areas are currently under restoration management of various types in both the Guanacaste and Tempisque Conservation Areas in Costa Rica. Such restoration is facilitated by the very presence of existing *in situ* reserves, but in practice it is rarely feasible elsewhere given the socioeconomic conditions prevalent in large parts of Mesoamerica. Even, for example, the establishment of Guanacaste National Park required the displacement of a human population living in, or farming, the area, with smaller farmers and squatters faring relatively poorly in the purchase and compensation process (Utting 1993). Nonetheless, in this case, sufficient national and international interest has probably been generated for the long-term maintenance of such management. Guanacaste, along with parts of Pacific lowland Mexico and the Yucatán Peninsula, however, represents the better end of the spectrum in terms of the size and quality of remnant dry-forest patches. Although, at a smaller scale, restoration ecology may have great relevance in the creation of

biological corridors between more or less intact areas of forest, it and traditional *in situ* conservation will be inappropriate for much of the rest of the Mesoamerican dry-forest life zone, given the highly degraded and patchy nature of the forest resource and prevailing socioeconomic conditions.

EX SITU CONSERVATION

Similarly, *ex situ* methods (e.g., seed banks, seed stands, botanic gardens) offer limited long-term potential for most tropical tree species. This is clear from the small number of tree taxa (some 100 worldwide, mainly of economic importance; National Research Council 1991) subject to effective *ex situ* conservation; the scientific, technical, and resource limitations that constrain *ex situ* programs (National Research Council 1991); and inherent deficiencies of *ex situ* populations as conservation gene pools (Brown et al. 1989).

CIRCA SITUM CONSERVATION

The limitations of both *in situ* and *ex situ* approaches, and the recognition that farmers maintain a large array of plant biodiversity in some traditional farming systems, have led to a re-examination of the potential role of "conservation through use" on farms (e.g., Maxted et al. 1997). The term *circa situm* (also "*circa situ*," "farmer-based conservation," "conservation *in hortus*"; Hughes 1998) has been used to distinguish the very different circumstances of conservation within altered agricultural landscapes (e.g., agroforestry systems, home gardens) outside natural habitats but within a species' native geographical range. Tree species have long been maintained, and hence conserved, in Mesoamerican agro-ecosystems. Hughes (1998) attributes the relative abundance of a wide range of *Leucaena* species in Mesoamerica, despite the loss of forest cover in most areas, to their management for several centuries by local communities and farmers in various ways and for various products and services. Indeed, he suggests that *L. salvadorensis* has been saved from extinction only because of its maintenance on farms, and there is also evidence for maintenance of genetic diversity within these on-farm populations (Chamberlain et al. 1996). Other examples of traditional management systems that maintain tree species are given for the dry-forest zone of Central America (Kass et al. 1993) and the Mixtec region of Guerrero, Mexico (Casas and Caballero 1996). Only recently, however, have tree conservation strategies sought to capitalize on such practices (e.g., Halladay and Gilmour 1995), and consequently there is much to learn if we are to realize the potential of *circa situm* strategies and appreciate their limitations. In essence, *circa situm* conservation requires identification of compatibility between natural resource management systems found in native ranges of priority species (in this case trees) and conservation objectives. Human inhabitants within such areas are thus recognized as agents of conservation. *Circa situm* conservation aims to integrate conservation with prevailing socioeconomic trends, whereas the *in situ* and *ex situ* types of conservation aim to remove areas and species from the influence of those trends.

FOCUS OF THIS CHAPTER

The focus of this chapter is to question the assumption that trees in scattered tropical agro-ecosystems have no long-term viability and therefore no role in conservation. We discuss the role *circa situm* approaches could play in conserving the tree species of the Mesoamerican dry forest. We are concerned here with the prospects for such an approach rather than the precise prescriptions that will need to be formulated independently for each species and situation. We do not propose that *circa situm* conservation can replace *in situ* conservation. Rather, we argue that for highly threatened, disturbed, and fragmented vegetation types, it could have an important complementary role. This may be through the conservation of particular species and genes not conserved *in situ* and/or the provision of additional habitat and the facilitation of gene flow between existing reserves. The potential gain is great if the many tree species that exist in such disturbed vegetation can be shown to be conservable there through existing land-use practices, thus freeing scarce resources for the conservation of more critically threatened species that require more conventional, resource-intensive approaches. Provision of effective *circa situm* options requires multidisciplinary research to establish the general potential for the integration of conservation and development and more specifically which species are, or could be, sustainably conserved in such systems, from both biological and human management perspectives. The utility of particular species will not guarantee their long-term conservation if, for example, genetic diversity and regeneration within critical populations are compromised. Conversely, maintenance of genetic diversity and adaptive capacity is irrelevant if current management drastically alters population persistence. We examine results from our ecological, genetic, and socioeconomic research conducted within dry forests of Costa Rica, Honduras, and Mexico, which overlap principally within southern Honduras. In particular, we consider results for two timber species, *Bombacopsis quinata* (Jacq.) Dugand, Bombacaceae, and *Swietenia humilis* Zucc., Meliaceae, both of local socioeconomic importance, with superficially similar ecology and considered of conservation concern (see the section "The Case Study Species" later in this chapter). We consider general principles that may influence under what conditions and for what species *circa situm* conservation will prove effective and how it might be implemented. Finally we highlight research and training needs to explore further the feasibility and implementation of this approach.

RESEARCH IN SOUTHERN HONDURAS

Our research has had a common focus in southern Honduras (taken here as the lowlands and foothills of the departments of Choluteca and Valle), an area within the dry subtropical life zone (Holdridge 1987) with a distinct dry season from October to May. The southern Honduran lowlands are mainly occupied by cattle pasture and export agriculture (cantaloupe, watermelon, sugarcane). The foothills show a fluctuating mosaic of land uses, with a predominance of basic grain production (*milpas*), alternating with fallows, some low-density cattle raising and, in more humid areas, low-intensity coffee production. The lack of mechanized tillage and the control of livestock movement typically allow natural regeneration of a highly variable range of tree species from seed banks, stumps, and newly arrived seed. From these species many farmers actively protect a subset of those most valued for a range of products (e.g., firewood and timber), reflecting a desire to optimize the use of available resources. Thus some trees reach, and remain in, reproductive maturity in *milpas* or pasture. Another subset of species remains as stumps and resprouts (up to 17,000 per hectare) simply because the removal cost is not perceived to produce adequate benefits (Barrance et al. in review). Many of these trees reach reproductive maturity during fallow periods. The area therefore presents suitable conditions in terms of forest patchiness, the surrounding forest-agriculture interface, and socioeconomic circumstances to allow the synthesis of results across research disciplines.

THE CASE STUDY SPECIES

Bombacopsis quinata is a medium- to large-size deciduous tree from Central America, Colombia, and Venezuela. It is hermaphroditic, largely self-incompatible (Sandiford 1998), and pollinated principally by the bat *Glossophaga soricina*. Its seeds are loosely attached to kapok, which facilitates their wind dispersal. Its timber is much in demand and has led to investment in large plantations, as well as planting by farmers within Central America. This species can be propagated by stakes and is used for living fences in parts of its range. Because of selective felling, deforestation, and destructive agricultural practices, this once common species is largely limited to isolated forest remnants. It is considered as endangered at the level of some populations (FAO 1986; Oldfield et al. 1998).

Swietenia humilis is a monoecious, medium-sized deciduous tree found along the Pacific

watershed of Central America and Mexico. It is pollinated by small butterflies, bees, and other insects, and its fruits contain large wind-dispersed seeds. Under controlled pollination it is self-incompatible (D. Boshier unpubl. data). Its sawn timber is highly valued, but commercial reforestation within its native range is hindered by the high incidence of attack by the shoot borer *Hypsipyla grandella*. Where populations of *S. humilis* and *S. macrophylla* are sympatric, hybridization is known, and their distinctness as species has been questioned (Styles 1981). Populations over much of the species' range have been reduced and fragmented, leading to its listing in 1973 in appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and classification as "vulnerable" by the International Union for Conservation of Nature and Natural Resources (IUCN) (Oldfield et al. 1998).

GENETIC DIVERSITY AND ITS MAINTENANCE

Evidence to date shows that a high proportion of tropical tree species are naturally outcrossing (e.g., Bawa et al. 1985), with associated risks from inbreeding such as reduced fertility, growth, and susceptibility to pests or diseases (e.g., Griffin 1990). Maintenance of genetic diversity is therefore vital for the long-term viability and adaptability of populations of many tree species. Reproductive biology, levels of genetic diversity and gene flow, and extent of localized adaptation have been studied within the native range of both *B. quinata* and *S. humilis* (see Sandiford 1998; White 1998; Billingham 1999; White et al. 1999; Boshier and Billingham 2000; and White and Boshier 2000 for methodologies and results). Remnant stands of secondary dry forest, confined principally to hillsides and remnant trees in pastures in the Punta Ratón region of the Honduran Pacific alluvial coastal plains, near Choluteca, were used, along with control plots in more continuous forest in both Honduras and Guanacaste, Costa Rica. The fragments varied in size (7–150 trees) and degree of spatial isolation (1–4.5 km). For both species, genetic markers (allozymes or microsatellites) showed that, at the degree of isolation studied, fragmentation did not impose a genetic barrier between remnants, direct measures of current mating patterns giving altered and proportionately higher levels of interfragment pollen flow over longer distances. Common to both controls and fragments for both species was a predominance of near neighbor mating (<300 m of the maternal tree). A large proportion of pollen donors were, however, from outside each fragment across the sampled area, indicating an extensive network of gene exchange at this spatial scale (16 km^2). So in two fragments (22 and 44 *S. humilis* trees), 62 percent and 53 percent, respectively, of pollen donors were from within the fragment, whereas 24 percent and 34 percent were from distances greater than 1.5 km and 3.6 km, respectively. There was no evidence for increased inbreeding in fragments, with both species continuing to show high levels of outcrossing even in the smallest fragments. Indeed, an *S. humilis* tree, "isolated" by 1.2 km from the nearest flowering trees, showed 100 percent external pollen sources, with more than 70 percent from trees in the main area of forest (>4.5 km), in accord with the species' self-incompatibility and in contrast to predictions that spatially isolated trees are more likely to deviate from random mating and receive pollen from fewer donors (Murawski and Hamrick 1991).

Such enhanced levels of long-distance gene flow into smaller fragments, also seen in *Spondias mombin* L. (Nason and Hamrick 1997), will potentially restore or maintain genetic variation in populations of these species within the modified environment. This contrasts with traditional views of the genetic effects of fragmenting populations whereby increases in spatial isolation and population size reduction have been considered to reduce gene flow between fragments (e.g., Saunders et al. 1991). Although the genetic effects of fragmentation are complex, for some tree species under fragmentation, pollination may occur over much greater distances than previously considered. The distance given here for *S. humilis* is more than ten times greater than that considered as distant by Chase et al. (1996) and more in accord with distances previously identified by zoologists (e.g., Janzen 1971; Frankie et al. 1976). There will, however, be a distance beyond which genetic isolation will occur, with associated problems for population viability and adaptation (see Young et al. 1996). Although determination is experimentally problematic, thresholds will vary between species depending on pollinator characteristics, availability, the specificity of the tree-pollinator relationship, and the presence and strength of any self-incompatibility mechanism. Self-compatible species that normally show some level of outcrossing (e.g., Murawski and Hamrick 1992) are likely to show increased levels of inbreeding at much shorter distances of separation (lower thresholds) than self-incompatible species.

PATTERNS OF DISTRIBUTION AT THE SPECIES LEVEL IN SOUTHERN HONDURAS

Two rapid botanical surveys (RBS) were undertaken to determine the tree and shrub species composition of the southern Honduras agroecosystem. The RBS technique follows the plotless or "unmeasured" sampling described by Hawthorne and Abu-Juam (1995), with minor modifications. A first, village-level survey consisted of species inventories in four rural communities selected nonrandomly to reflect regional variation across socioeconomic and environmental gradients. Within each community 20 households were selected along a socioeconomic gradient and a random subset of land units selected for inventory from those farmed by these families. Land unit categories followed definitions given by householders. In each land unit species were scored as present or absent, a species being considered present if it could be identified as a woody individual, such that live stumps were included. A second, forest-level survey inventoried tree diversity in a subset of forest patches in southern Honduras. Forests were selected nonrandomly to maximize geographical spread and biased toward the few remaining relatively large forest areas (i.e., >50 ha). All forests appeared to be largely, if not completely, composed of secondary regeneration of varying ages. Primary dry forest apparently no longer exists in southern Honduras, although it is probable that some older trees are remnants of much older forests (White et al. 1999). The forest cover that does remain is composed of stands of trees of as little as 2 ha in area and rarely greater than 20 ha, areas usually considered too small to be of value to conservation practitioners.

The two species differ in terms of where they occur. *S. humilis,* one of the most commonly encountered species (only 7 of more than 250 woody species identified were found more often), was found as frequently in farmland as in forests (table 16.1). In contrast, *B. quinata* was found less than *S. humilis,* but much more often in forests than on farmland. Both species were more common in fallows, fields, and pastures (table 16.1), which are typified as naturally regenerating management systems, than in home gardens and orchards, where planting is more typical. Both species also showed considerable variation in occurrence between the four communities (table 16.1), probably owing to a combination of biological and anthropogenic factors, although in southern Honduras a lack of undisturbed dry forest where the two species are sympatric makes it difficult to distinguish the principal factors. Two of the larger forests in Choluteca suggest that both species may show similar levels of occurrence in mature forest. In relatively undisturbed semievergreen forest on Cerro Guanacaure, *B. quinata* is common, as is *S. humilis* (J. Gordon pers. obs.). On Cerro Las Tablas, one of the most mature secondary forests in the area, many mature trees of *B. quinata* and *S. humilis* occur (densities up to 17.0 and 9.6 per ha, respectively). In Costa Rica both species occur at similar levels in more undisturbed areas of protected dry forest (e.g., Lomas Barbudal, Playa Nancite mature forest area; table 16.2). Thus, we have grounds to speculate that in southern Honduras the relatively low occurrence of *B. quinata* on farms results, at least in part, from unfavorable management practices (further discussed later in this chapter) rather than a natural tendency toward low densities.

TABLE 16.1

Occurrence of Bombacopsis quinata *and* Swietenia humilis *by Land Use and Community in Southern Honduras, 1999*

LAND USE	TOTAL NUMBER OF SAMPLES	PERCENTAGE CONTAINING *B. QUINATA*	PERCENTAGE CONTAINING *S. HUMILIS*
Forest	48	27	52
Farm	105	11	56
Fallow, field, and pasture	58	16	67
Home garden and orchard	47	4	36
COMMUNITY/DEPARTMENT			
San Juan Arriba, Choluteca	25	12	4
Agua Zarca, Valle	38	5	74
San José de las Conchas, Choluteca	24	17	46
Los Coyotes, Choluteca	25	16	64

The common on-farm occurrence of *S. humilis* cannot be explained simply by farmer preference (see the section "Patterns of Management of *B. quinata* and *S. humilis* in Southern Honduras" later in this chapter), given that natural regeneration has to occur before farmers can aid its recruitment. *S. humilis*, like its close relative *S. macrophylla* King, undoubtedly thrives in regimes of heavy disturbance (Snook 1996) as provided by traditional agriculture in southern Honduras. Once established, it can survive for decades in the closed forests that may form when fallows are abandoned. Gerhardt (1994) showed that germination of *S. macrophylla* in Guanacaste was not affected by differences in light levels and could establish equally well in pasture and young secondary forest. A study of localized adaptation in both Costa Rica and Honduras, with seedlings in pasture and secondary and mature forest, showed zero survival of *B. quinata* at three years of age in any of these land uses, compared with 15–60 percent for *S. humilis* (M. R. Billingham and D. H. Boshier unpubl. data). This is borne out at Playa Nancite (Santa Rosa National Park), where *S. humilis* regeneration in adjoining areas of abandoned degraded pasture (table 16.2) is abundant and that of *B. quinata* nonexistent. In contrast to other predictions and some studies (e.g., Ghazoul et al. 1998), seed production of *S. humilis* (table 16.3) was also more reliable and higher in disturbed environments than in closed forest, whereas that of *B. quinata* showed no differences by forest type, except at Playa Nancite, where it was low in all four fruiting seasons. During this period 13 percent of the *B. quinata* trees at Playa Nancite died from apparent old age/creepers/wind. Given the lack of any regeneration, the future of *B. quinata* at this site, although it is within a protected area, seems insecure. Indeed, fires and tree felling evident over four years (table 16.2) confirm threats to both species, even within "protected" areas.

We can conclude that species are likely to be scattered nonrandomly in the various land-use types and communities of an agro-ecosystem and that these distribution patterns must be known for *circa situm* conservation options to be assessed and for strategies to be devised and implemented. The fact that 76 percent of the species identified in the surveys were found in

TABLE 16.2

Mortality of Bombacopsis quinata *and* Swietenia humilis *Trees over a Four-Year Period at Sites in Costa Rica and Honduras*

SPECIES	SITE	COUNTRY	SITE TYPE	AREA STUDIED (HA)	NO. OF TREES	MEAN DBH IN CM (S.D.)	PERCENTAGE OF TREES CUT/DEAD
B. quinata	Lomas Barbudal Biological Reserve	Costa Rica	Protected area	25	61	69.2 (25.5)	0/6.6[a]
	Playa Nancite, Santa Rosa National Park	Costa Rica	Protected area/ mature	28	62	71.6 (42.8)	0/12.9
	Playa Nancite, Santa Rosa National Park	Costa Rica	Protected area/ regeneration	3	0		
	Punta Ratón, Choluteca	Honduras	Private forest/ farm	240	172	54.2 (20.9)	8.1/5.8[a]
S. humilis	Lomas Barbudal Biological Reserve[b]	Costa Rica	Protected area	25	57	47.4 (17.0)	0/14.0[a]
	Playa Nancite, Santa Rosa National Park	Costa Rica	Protected area/ mature	28	156	46.7 (16.0)	0/5.8
	Playa Nancite, Santa Rosa National Park	Costa Rica	Protected area/ regeneration	3	23	20.3 (3.7)	0/0
	Cerro Las Tablas, Choluteca	Honduras	Private forest/ farm	68	105	41.9 (14.0)	25.7/1.9
	Punta Ratón, Choluteca	Honduras	Private forest/ farm	240	75	37.9 (14.1)	5.3/5.3

Note: Mortality occurred through either natural causes or human intervention. dbh = Diameter at breast height.
[a]Killed by 1994 fire.
[b]Possibly *S. macrophylla* or *S. macrophylla* × *S. humilis*.

TABLE 16.3

Percentage of Bombacopsis quinata *and* Swietenia humilis *Trees per Year with Moderate to Heavy Seed Production at Various Sites*

SPECIES	SITE[a]	SAMPLE SIZE[b]	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)
B. quinata	Lomas Barbudal	>45	70.6	66.7		68.9	
	Playa Nancite	>30	61.5	56.4	55.2	31.5	
	Punta Ratón	>105	76.4	61.9	73.3	90.1	
S. humilis	Lomas Barbudal	>46		12.1	0.0	16.3	20.8
	Playa Nancite	>143		32.9	11.0	18.4	17.2
	Cerro Las Tablas	>61		48.7	12.6	29.5	44.6
	Punta Ratón	>45	28.0	36.1	42.2	49.1	33.3
	Comayagua	30	66.7		60.0	83.3	76.7

Note: Moderate to heavy seed production for *B. quinata* is more than 20 seed capsules; for *S. humilis,* more than 10 seed capsules.
[a]Sites are ranked for increasing degree of disturbance: Lomas Barbudal, relatively undisturbed area within a reserve; Playa Nancite, area of the Santa Rosa National Park with disturbance; Cerro Las Tablas, forest with remnant trees and secondary regeneration; Punta Ratón, remnant trees and secondary regeneration in small fragments and pasture; Comayagua, planted trees by roadside.
[b]Sample size varies from year to year owing to mortality.

agro-ecosystems (i.e., not limited to forest) emphasizes the potential for on-farm trees to make a contribution to conservation strategies. This is borne out by Harvey and Haber (1999), who found 190 tree species in 237 ha of upland pasture near Monteverde Reserve in Costa Rica. Assuming that greater occurrence means greater conservation potential, the potential for different sites to be the foci of successful *circa situm* conservation will vary. For example, taking the distribution evidence in isolation, the Agua Zarca community has a high potential for conservation of *S. humilis* but very little for *B. quinata* (table 16.1). *S. humilis* appears ecologically suited to *circa situm* conservation "through use" on these farms, where tillage is minimal, livestock movement controlled, and fallows sporadically allowed. *B. quinata,* however, appears less suited, being much more susceptible to reductions in forest cover, although even for such species that appear to be predominantly "forest species," the relatively few individuals on farms may be important for gene flow between forests (see the section "Genetic Diversity and Its Maintenance" earlier in this chapter). Evidently conservation strategies for these two species need to be very different.

PATTERNS OF MANAGEMENT OF *B. QUINATA* AND *S. HUMILIS* IN SOUTHERN HONDURAS

A study in the same small farmer communities where village-level species inventories were taken (see previous section) shows that, in addition to differences in reproductive biology, ecology, and local distribution, *B. quinata* and *S. humilis* differ in management by local people. In general, within these communities, people mentioned that many of the same tree species under active protection are also used for timber, although there was a marked contrast between the frequency of active protection for *S. humilis* (second only to *Cordia alliodora*) and that of *B. quinata* (table 16.4).

A focal group meeting in Los Coyotes, where species were rated for present and past use, also revealed marked differences between the two species in terms of their past and present socio-

TABLE 16.4

Principal Tree Species Mentioned as Used for Timber or Actively Protected within Agricultural Areas as Sources of Timber or Posts in Four Communities in Southern Honduras in 1998

SPECIES USED	PERCENTAGE OF INTERVIEWEES[a]	SPECIES PROTECTED	PERCENTAGE OF INTERVIEWEES[a]
Cordia alliodora	84.8	*Cordia alliodora*	38.0
Bombacopsis quinata	20.3	*Swietenia humilis*	22.8
Enterolobium cyclocarpum	19.0	*Lysiloma* spp.	20.3
Albizia saman	16.5	*Enterolobium cyclocarpum*	10.1
Lysiloma spp.	16.5	*Albizia saman*	10.1
Swietenia humilis	16.5	42 other tree species, including *Bombacopsis quinata*	1.3–6.3 each
Calycophyllum candidissimum	15.2		
Cedrela odorata	15.2		
Conocarpus/Rhizopora spp. (mangrove)	15.2		
Simarouba glauca	11.4		

Note: The four communities were San Juan Arriba, Agua Zarca, San José de las Conchas, and Los Coyotes.
[a]Figures given as a percentage of 79 interviewees.

economic niches. Previously ("in the time of their grandfathers") *B. quinata* was almost the only species used for timber; however, its exploitation to supply furniture workshops in the nearby town of El Triunfo led to a large decrease in its numbers in the area. Farmers now use a broad range of previously little-used species, including *S. humilis,* others of which (e.g., *Guazuma ulmifolia* Lam) have far inferior timber value. Farmers also contrasted previous management during field clearance, whereby many valuable timber trees were felled and burned on-site or used for firewood, with current practices, whereby valued trees are protected and only timber offcuts used as firewood.

Apparently because of a scarcity of off-field tree resources, resulting from high human population densities and growth rates, many farmers, by favoring certain species during clearance, protect and manage valued trees within their fields to meet their subsistence needs and as a naturally regenerated cash crop. Furthermore, stumps and seeds survive regardless of felling, as stump removal is difficult and mechanical tillage is rarely practiced owing to topographical constraints. Farmers are also adept at controlling grazing, a prerequisite of successful maize cultivation, so that livestock does not necessarily prevent regeneration and indeed may facilitate it (Janzen 1986a). Patches of fallow and forest within the mosaic continue, despite their small size, to be propagule sources of many of the species found in these fields. Up to certain limits the benefits of maintaining trees outweigh negative effects (e.g., shade) that farmers perceive the trees to have on crops (Barrance et al. in review). This form of management represents a rational response to resource scarcity rather than a desire to conserve biological diversity per se.

The relatively low frequency of protection of *B. quinata* in fields (tables 16.1, 16.4) does not appear to result from its being less valued than *S. humilis* or from differences in farmers' perceptions of tree/crop interactions (no important negative interactions were reported by farmers between either species and crops). A more probable explanation is the relative scarcity and patchy distribution of *B. quinata* natural regeneration, particularly in fields. Farmers protect it where they find it but find it much less frequently than *S. humilis*. The current scarcity of *B. quinata* appears to stem, at least in part, from its past overexploitation, prior to the self-imposition of tree management controls by farmers as a response to scarcity and its ecological characteristics. *S. humilis* differs in that it appears to have been rather less valued than *B. quinata* and as a result largely escaped overexploitation. It now benefits from the current practice of active protection of the remaining valued species and its ease of regeneration. However, despite farmers' clear preference for both species and their promotion by extension agencies, neither species is commonly planted. This probably reflects the cost of planted trees, compared with "free" natural regeneration and possibly the greater risks to planted trees from cattle that are periodically introduced into *milpas* to eat crop residues.

Both *B. quinata* and *S. humilis* also occur in forest patches and pastures within larger estates (e.g., Cerro Las Tablas), although the management systems and socioeconomic conditions are very different from those found in the small farmer communities. In both pasture and forest remnants on these estates there appears to be a continued decline due to piecemeal felling (table 16.2), possibly as the landowners do not face the same conditions of overall resource scarcity that motivate small farmers to nurture natural regeneration. In addition, conditions in many pastures (they are normally destumped on clearing and then periodically burned to encourage grass development) are less propitious to tree regeneration than those on steeper land under subsistence production systems.

CONCLUSIONS

In situ conservation of the remaining areas of mature Mesoamerican dry forest is likely to be the most effective and efficient means of safeguarding a substantial part of the threatened specific and subspecific tree diversity of this forest type. However, many species and populations of concern are not well or not at all represented in such areas and require a different approach. Habitat restoration may also have a role, but the socioeconomic conditions that make this a possibility are uncommon, and costs may be prohibitive. *Circa situm* conservation has much to offer in these situations but also significant limitations; for it to be effective, its application must be guided by information from multidisciplinary research of the type discussed in this chapter. As the contrasting examples of *B. quinata* and *S. humilis* show, we cannot permit ourselves the luxury of assuming that all species are likely to persist in an agricultural mosaic until this is proved otherwise. However, on the basis of such evidence, neither should we underestimate the capability of many species to persist in large numbers in these agro-ecosystems under current practices, as this could lead to the misdirection of limited conservation resources toward species not under threat. *Circa situm* conservation of tree diversity is already occurring, albeit as a side effect of resource-poor farmer practices. Given apparently similar conditions across large parts of the dry zone foothills of El Salvador, Guatemala, and Nicaragua, *circa situm* populations may represent a considerable conservation resource. If conservation planners were to take this resource into consideration, how many species currently assumed to be threatened by habitat loss might prove to be thriving (Vandermeer and Perfecto 1997)?

An enhanced future role for *circa situm* conservation in the dry tropics of Mesoamerica will depend principally on the existence of species of conservation importance in the agro-ecosystems and forests in question. Species of widespread occurrence whose status does not appear about to change and species well represented in adequately protected areas should not attract more of the scarce resources available for conservation. Are agro-ecosystems likely to contain the types of species we wish to conserve? To answer this question we offer the following generalizations. Agro-ecosystems are highly disturbed in comparison with the original vegetation, and the dominant species are likely to be either "preadapted" to disturbance (i.e., weedy, pioneer, and/or coppicing) or positively selected by farmers (or both). The long-distance dispersal propagules of these typically pioneer type species, coupled with ever increasing disturbance, ensure that they will generally not be conservation priorities. One priority must therefore be the relatively few species with much narrower distributions, endemic to areas now completely converted to agro-ecosystems (e.g., *Leucaena salvadorensis;* Hellin and Hughes 1993). For these species *in situ* is de facto, not a conservation option. A second priority would be those species and species assemblages whose continued *in situ* conservation would be enhanced by their conservation *circa situm*. Here conservation in agro-ecosystems between reserves increases habitat area, connectivity, and population sizes.

Knowledge of which tree species occur where says nothing about the species' viability within an agro-ecosystem. The effects of fragmentation and the regeneration of secondary forest patches are likely to be dynamic, and to ensure that we deal with populations with a long-term future, we must carefully consider the reproductive and regenerative capacities of priority species and the perpetuation of management practices that allow natural or artificial regeneration. Yet knowledge of the effects of human interventions (e.g., logging, fragmentation) on tree gene pools is relatively poor. We do not know at what stage forest fragments become genetically isolated; nor do we understand the consequences of gene flow between managed and remnant natural populations. Selection pressures exerted by farmers, intentionally or unintentionally, at species, population, and within-population levels are also little understood, and their compatibility with conservation objectives are unclear.

For the species studied here and others elsewhere (e.g., chapter 3), it appears that descriptions of remnant trees and forest patches as "isolated" or "living dead" (Janzen 1986b), with little or no conservation value, may be misleading and more human perception than a true reflection of actual gene flow and any biological reality. It is more realistic to view remnant forests not as islands but rather as existing within a mosaic of land uses that differ in their capacity to provide habitat or permit movement for any organism. In this sense it is important to recognize the complementary habitat role that maintenance of trees on farms is already playing to *in situ* dry-forest conservation. With adequate gene flow and seed production, some remnant forest patches and trees may be important contributors to connectivity and conservation, both *in situ* and *circa situm*, more generally. The capacity of some pollinators to move long distances has been shown, although the potential to move between patches will depend on their behavioral response to such a mosaic. Some bat species move preferentially down forest tracks and pathways (e.g., Estrada et al. 1993). Whereas some bee species are generally restricted in their movements (Powell and Powell 1987), most show some long-distance movements, and some will move more than 4 km across agro-ecosystems between forest patches (e.g., Frankie et al. 1976; Raw 1989). With a range of nonspecialist pollinators, pollen flow dynamics in *S. humilis* are probably far less susceptible to habitat disturbance than tree species with more specialist pollinators, although *Ficus* species, with species-specific wasp pollinators, may form extensive metapopulations in fragmented landscapes (Nason et al. 1998). Changes in pollinator assemblages in fragmented landscapes may strongly affect patterns of gene flow and reproduction in remnant tree populations. Concerns that declines in pollinator populations in such agro-ecosystems may eventually limit tree reproduction require monitoring of numbers, as well as

evidence for pollinator limitation (Allen-Wardell et al. 1998).

Active tree protection by farmers is strongly dependent on their perceptions of the trees' potential value to them and on other community members' recognition of their ownership rights to the trees. However, the *B. quinata* case clearly demonstrates that even if a species is valued its conservation is not guaranteed (Gordon et al. 2003). In fact, *use value* may lead to a species' decline until a threshold is reached whereby farmers are obliged to modify their practices if they wish to ensure a continued supply. It appears that at this point the rate of decline of many species tends to level out as mature individuals are managed on a more rational basis and removals replaced by natural regeneration that receives active protection by farmers. However, if regeneration is poor in agro-ecosystems, as appears to be so for *B. quinata*, it may continue to decline and disappear. Alternatively farmers may switch much of their demand for a particular product to another species.

Hughes (1998) suggests that *circa situm* conservation is probably limited to species that tolerate disturbance and are actively used and preferred by farmers. However, although it indeed favors disturbance-tolerant species, the examples from southern Honduras and those of Kass et al. (1993) suggest its applicability to a broader range of species than just the actively preferred ones. However, survival of nonpreferred species may to a large extent depend on the technology level of land management practices; for example, a larger number of stumps of nonvalued coppicing species is allowed to persist in low-intensity swidden agriculture of southern Honduran hillsides than in ploughed fields of the central valleys of Oaxaca, Mexico. It would be unfair to promote conservation initiatives at a landscape scale across the Mesoamerican dry zone that prevent poor farmers from adopting more profitable practices, although in many parts there are significant biophysical constraints (e.g., topography, resource availability) to those seeking to intensify production. At least in southern Honduras there appears to be little immediate risk of agricultural intensification leading to massive extinctions (cf. Janzen 1986b). *Circa situm* conservation strategies are more likely to be effective when planned on a species-by-species basis, within the farming systems context of a particular area, with resources focused on target species so as to minimize negative socioeconomic effects. The "area" or "management unit" over which such strategies would operate would be measured in numbers of participating households or land units in which target species conservation is successfully incorporated into existing, or acceptable, farm management practices.

The prospects for *circa situm* conservation for *S. humilis* appear good, but less so for *B. quinata*, and it is ironic that of these two species the former is the one afforded more protection by international convention (appendix II of CITES). However, for it or similar species, some monitoring may be advisable to ensure that its niche in the farming system is maintained in the face of changing socioeconomic trends. Current trends, at least in some areas, involve an iterative process of property subdivision and elimination of forest and fallow areas, with a corresponding increase in numbers of trees in grain fields and pastures. It is possible that farm size will eventually reach a threshold beyond which farmers are unwilling to divide their property further among their heirs, and increased dependence on off-farm income sources will divert pressure from land and tree resources, leading to a stable situation. However, it is unclear at what point a threshold will be reached, to what degree this will be influenced by available off-farm income, and whether farm size reductions will lead farmers to increase tree densities on farms to satisfy tree product needs or reduce them to increase basic grain yields. The challenge offered by *circa situm* conservation is to adapt to these changes over a relatively wide geographical area rather than seek to halt such processes within a confined area such as a reserve. To this end there is a need to raise awareness among development professionals of the value of natural regeneration as both conservation and socioeconomic resources. Efforts to promote planting and the use of multipurpose or exotic tree species (or both) at the expense of natural regeneration may have deleterious effects not only on conservation but also on farmer welfare. This would be evident through a reduction in the range of forest products normally available to farmers from natural regeneration and an increased cost of tree establishment.

RECOMMENDATIONS FOR RESEARCH AND TRAINING

The data requirements to answer the questions raised in this chapter are considerable, and realization of the potential of *circa situm* conservation requires a range of actions. For *circa situm* conservation to have anything but a minor role in the conservation of tropical forest resources, priorities among species and forest types will need to be set and shortcuts found. We end this chapter by listing recommendations for research and dissemination priorities for the further development of *circa situm* conservation. The list is neither prescriptive nor exhaustive and reflects primarily the situation as we understand it in southern Honduras. It is presented to illustrate the types of information demands that *circa situm* prescriptions will make. However, overriding such specificity is the need for conservation planners, more accustomed to *in situ* methods, to consider the possibility that populations of trees found outside protected areas have a role in the conservation of biodiversity. This in turn will require the direct involvement of development organizations in biodiversity conservation and an effective two-way communication between them and "traditional" conservation organizations to ensure both conservation and development benefits.

- Species distribution patterns need to be established not only at a broad level, to identify species that are rare and therefore a conservation priority, but also at a finer scale, to identify which species are not conserved *in situ* and which land uses within an agro-ecosystem are most appropriate for each species.
- Targeted tree populations need to be described in terms of size class distributions with respect to reproductive maturity. We cannot assume that a *circa situm* population contains the same proportion of reproductively active individuals as an *in situ* population.
- Fragmentation thresholds for gene flow need to be determined and the possible selection pressures exerted by farmers further elucidated.
- Species of conservation concern within agro-ecosystems need to be understood and classified in terms of farmers' perceptions of their value. Species guilds need to be defined, combining biological and socioeconomic variables to reduce, by extrapolation, the information demands of *circa situm* conservation.
- Education and training curricula need to be broadened so that more conservation biologists recognize the potential role of on-farm conservation and more rural development practitioners recognize their role in biodiversity conservation.
- The complementary habitat benefits of different agro-ecosystems for conservation need to be evaluated, recognized, and promoted.
- Rapid rural appraisal techniques (see Chambers and Guijt 1995) need adapting and testing for their ability to provide adequate and cost-effective information for *circa situm* management.
- Strategies need to be explored on a species-by-species basis to ensure effective use of resources and minimum disruption to farming practices.
- The costs/benefits to farmers of actively promoting conservation through a *circa situm* approach need to be carefully balanced and, if necessary, forms of compensation considered.
- Effective systems for long-term monitoring of the biological (e.g., pollinator levels, regeneration levels) and socioeconomic

dynamics (e.g., management practice changes) of conservation need to be established.

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PART TWO

Transferring Biodiversity Knowledge into Action

The Record

Savannas and Dry Forests

Linking People with Nature

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ASHGATE

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Chapter Three

Trends, Cycles and Entry Points in the Dry Forest Landscapes of Southern Honduras and Coastal Oaxaca

Adrian Barrance, Jamie Gordon and Kate Schreckenberg

Introduction

It is probable that Mesoamerican Tropical Dry Forest (MTDF) originally stretched virtually unbroken along almost the whole of the Pacific slopes of Mesoamerica, from sea level up to 800m or more, and also in the numerous valleys of the interior of the isthmus and the western, leeward side of the Yucatán Peninsula in Mexico. Today, however, dry forest landscapes vary widely across Mesoamerica in the degree to which they have been affected by fragmentation and conversion for agriculture. This chapter considers the different landscapes found in two contrasting study areas, southern Honduras[1] and coastal Oaxaca,[2] and examines the factors and interactions which have led to the formation of each. Between them, these two study areas reflect much of the diversity of biophysical, socio-cultural and policy/legal conditions that may be found across Mesoamerica. Southern Honduras is in many respects typical of the highly disturbed 'agroecosystem' that dominates much of Central America, where the original tree cover has largely been lost and land tenure is largely individual in nature. Coastal Oaxaca, by contrast, still contains large areas of mature and relatively undisturbed dry forest (far more extensive than the largest remnants in Nicaragua or Costa Rica, for example), and tenure is largely communal in nature.

The chapter discusses the dry forest in these two areas from a number of perspectives. Firstly, we distinguish different landscape types according to their social and biophysical characteristics and appearance, attempting to categorize and organize them using the concept of 'hierarchical patches' (*sensu* Wu and Loucks, 1995). This first categorization is based exclusively on observation and does not explore function. We then attempt a more functional analysis, considering the dry forest as a 'system' and defining the different subsystems which make up the system as a whole, and the different components and factors which make up each subsystem. Then, we discuss in detail the processes occurring within the subsystems and the relationships between subsystems. Finally, we examine the characteristics of the processes and relationships described, for example their linear or cyclical nature, and on the basis of this discuss the stability of the system as a

whole and some key 'entry points' for policy interventions that may promote desirable and sustainable outcomes in the systems, in terms of the resulting socioeconomic and biophysical conditions.

The article is based on the results of the interdisciplinary research project 'Conservation of Tree Species Diversity in Fragmented Mesoamerican Dry Forest'.[3] As such, it places particular emphasis on the tree component within the overall dry forest 'system', and how this determines, and is determined by, other components of the system.

Methods

The study was carried out by teams of botanical and socioeconomic researchers working in parallel. In each of the two case study areas, the researchers non-randomly selected four rural communities, chosen to reflect the diversity of conditions prevalent in each area. Criteria used in the selection included forest cover, land use, market access and tenure. The locations of the study communities are shown in Figure 3.1 and the key characteristics which differentiate the communities studied are summarized in Table 3.1.

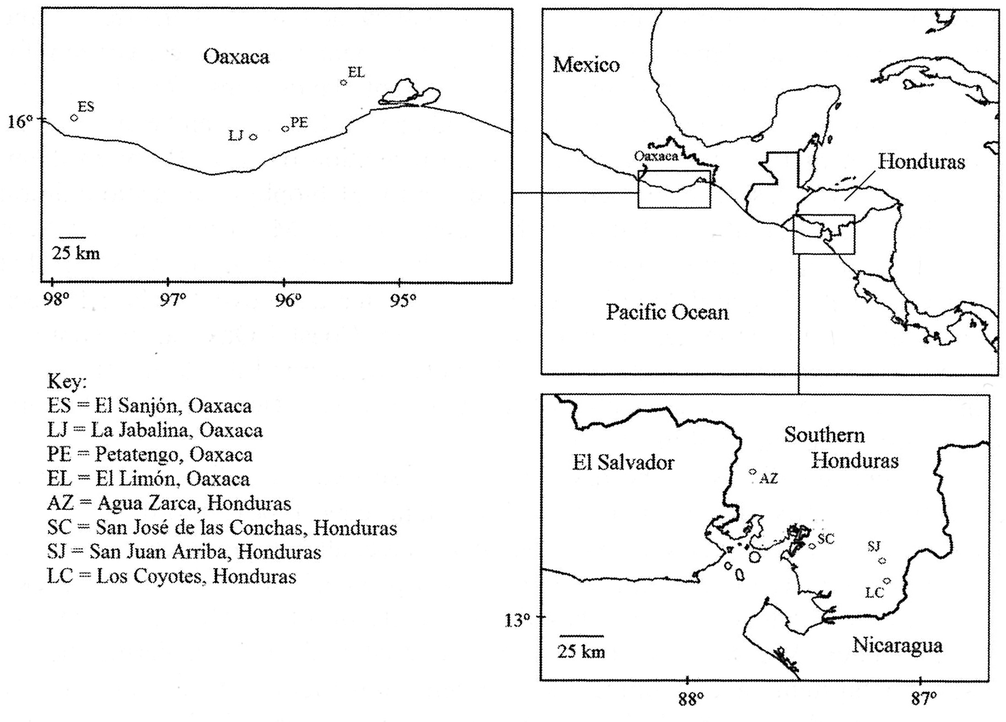

Figure 3.1 Location of study communities in southern Honduras and Oaxaca

Table 3.1 Key characteristics of the study communities

Study area	Community	Key characteristics
Honduras	San Juan Arriba	Steep topography, relatively good market access, much fruit and coffee production.
	Agua Zarca	Steep topography, poor market access
	San José de las Conchas	Includes both coastal flats and hill outlier; good access to employment, much cattle ranching
	Los Coyotes	Good access to markets for tree products
Oaxaca	La Jabalina	Communally managed lands, large areas of forest remaining, good access to paid employment
	El Sanjón	Flat coastal lowlands, largely individual land holdings, good access to employment and markets
	Petatengo	Communally managed lands, relatively poor market access
	El Limón	Ejidal lands, relatively good market access

In each of these communities, a sample of farmers was randomly selected across the range of socioeconomic strata. The botanical team then carried out plotless sampling of the tree species present in the different land units of each farmer. This farm level work was supplemented by additional botanical sampling in forest and fallow areas outside of the study communities themselves (Gordon *et al.*, 2004). In addition, detailed quantitative inventories were carried out of the numbers and identities of trees, including standing individuals, live stumps and seedlings, on a sub-set of farms.

The socioeconomic team, meanwhile, carried out semi-structured interviews and field visits to study the farmers' perceptions of, and relations with, the tree resource. These interviews also permitted the collection of historical information on landscape changes. Landscape changes were studied at a more macro level through the examination of aerial photographs dating from 1954 and 1983 (in the case of Honduras) and the mid 1980s (in the case of Oaxaca). Methods and the results of the farm level research are presented in more detail in Barrance *et al.* (2003) and Gordon *et al.* (2003).

Hierarchical Patches and Landscapes

The researcher, on travelling through the two study areas or studying aerial photographs of them, will be impressed by the diversity of landscapes encountered. Topography ranges from flat to hilly; the vegetation ranges from apparently mature forest to extensive areas of commercial agriculture and pasture; land units vary from large plots clearly defined by fences to a hotchpotch of fallows, staple grain fields and small woodlands of irregular shape and size, which often blend into each other without clear boundaries. It is evident that this diversity of landscapes is the

result of a diversity of management approaches. To understand these, it is necessary first to organize one's thoughts, by means of an initial classification of the landscapes. Here we do this according to two criteria: the scale of the landscape units and the degree to which they show interchangeability (defined as reversible conversion between land uses) over time.

The result of an initial ranking by scale of the different units, or 'patches' (*sensu* Wu and Loucks, 1995) is shown in Figure 3.2. The highest level of classification by scale, within the MTDF as a whole, is the topographical unit: both study areas can clearly be divided into hill lands and lowlands (flat coastal plains). The lowest level is defined by present day land use: in both study areas we can observe staple grain fields (*milpas*), fallows, small woodlands, hill pastures, lowland pastures and commercial agricultural units.

Hill lands

On the hills of both study areas, the introduction of a temporal dimension permits the definition of an intermediate level of landscape: this is the 'steep land cyclical agro-ecosystem', made up of *milpas*, fallows, small woodlands and many pastures. These different land uses are not in fact discrete units but are in a state of cyclical flux; following several years of cultivation, *milpas* are typically converted to pasture for a period and then left to fallow (in other cases, *milpas* are converted directly to fallow), and in some cases fallows are left for sufficient time for them to develop into closed canopy woodlands. The frequency at which the cycle operates and the duration of its respective components vary, both within and between the two study areas; in areas with high population pressure, the duration of the fallow component is typically reduced and there is consequently less area of fallow in the landscape relative to areas under active cultivation. By contrast, in parts of coastal Oaxaca, for example between the central forest area around Santa María Huatulco and the eastern limit of the study zone in the Isthmus of Tehuantepec, mature fallows dominate the landscape.

On the hill lands of both study areas, there is in addition a number of more permanent land use types, which are typically less interchangeable over time with the elements of the cyclical agroecosystem described above. These include home gardens (*solares*), which are normally located immediately around the house and are dominated by planted fruit trees; permanent pastures, which tend to be more extensive in area than the temporary pastures in the cyclical agro-ecosystem; and, in Oaxaca but not southern Honduras, extensive areas of apparently mature and largely intact forest. However, the distinction between the apparently permanent pastures and the mature forest on the one hand, and the cyclical agroecosystem on the other, is at times blurred; pastures may in some cases become overgrown and effectively return to fallow, while it is possible that significant areas of apparently undisturbed forest have at some time in the past been cleared for agriculture and subsequently left to regenerate.

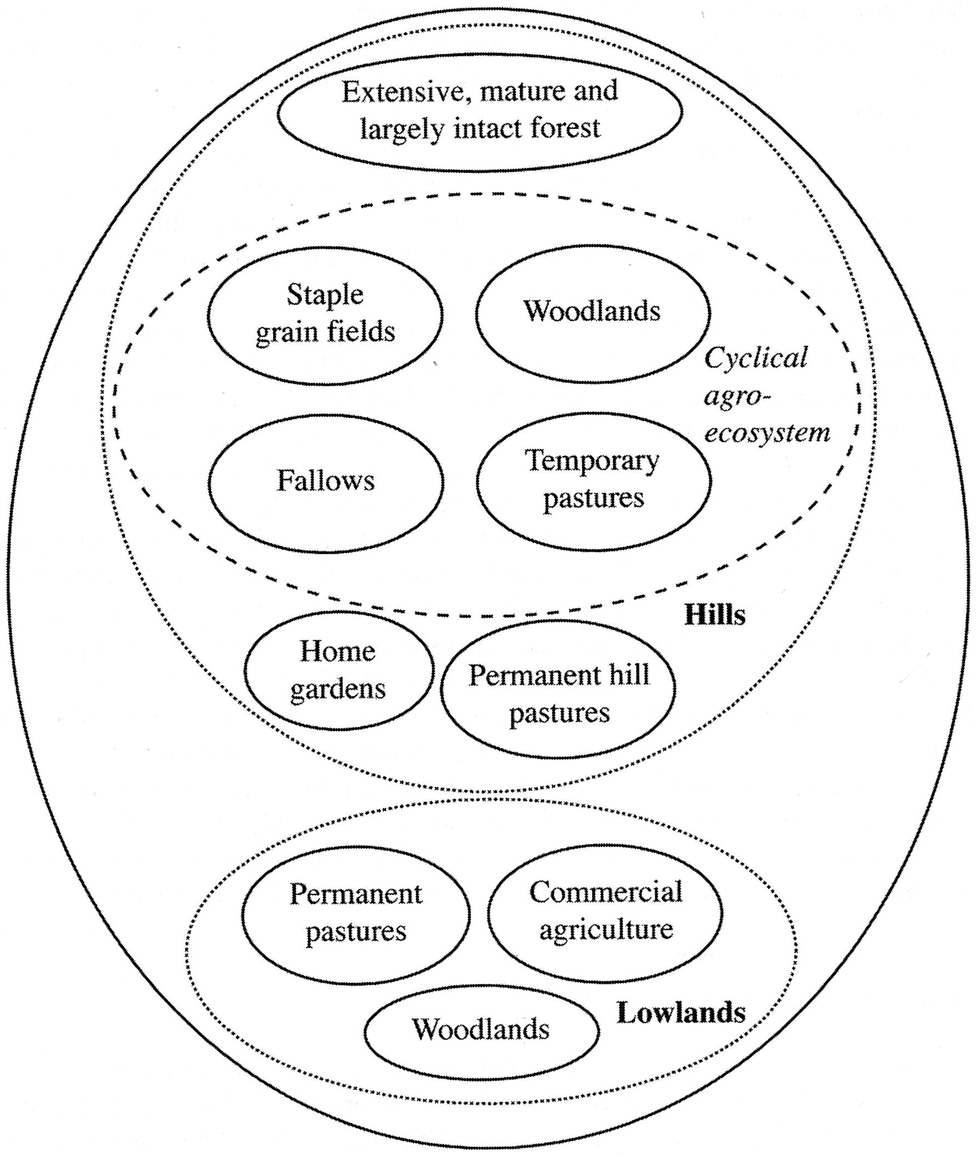

Figure 3.2 Landscape units within the MTDF of southern Honduras and Mexico

Lowlands

In the other main topographical unit that can be distinguished in both study areas, the lowlands, the land uses are rather different from those on the hills. In both areas, the coastal plains include much commercial agriculture, for example cantaloupe melons and water melons in southern Honduras and lemon plantations in coastal Oaxaca. There are also large expanses of cattle pasture, much of which, especially

in southern Honduras, is poorly managed and supports very low herd densities. Scattered throughout the lowlands are woodlands of varying size, in many cases located on steep hill outliers which poke up through the fertile plains. These owe their survival to their location on steep land, together with the fact that they often lie within large estates. Typically, however, they have been subject to high levels of intervention, for example through timber extraction or extensive livestock browsing.

In general, there is much less evidence of interchangeability over time between land units on the lowlands than on the hills, due largely to the fact that the favourable topographical conditions allow the intensification of agriculture, involving the use of artificial fertilizers, rather than fallowing, to maintain fertility over time. Despite this low level of interchangeability, the social dynamics and scale of the different units described in the lowlands are similar. This applies even to the outlier woodlands within the lowlands, which are generally controlled by the same people as own the pastures and commercial agriculture areas. It therefore makes sense to call the 'coastal lowlands' one discrete landscape.

For reasons of space, we have used one diagram to depict both study areas. However there are important differences between the two study areas which justify their landscapes being considered as distinctive, rather than, for example, one 'Mesoamerican steep land cyclical agroecosystem'. One difference is the generally greater proportion of fallows in the Oaxacan cyclical agrosystem, relative to its Honduran counterpart. Another is the contrasting tenure situations in the two areas: virtually all land in southern Honduras is privately owned (although actual titles are often lacking or of dubious validity), whereas a large proportion of the land in the Oaxacan study area is communally owned. At this stage in our analysis we will limit ourselves to this observation; the importance of this distinction will become more evident when we apply alternative, more functional, forms of analysis.

Functional Components of the MTDF

The system presented in Figure 3.3 depicts the dry forest in terms of its functional components, rather than just its observable characteristics. It holds true in general terms for each of the landscapes found in the study areas. Observed variations between landscapes are determined by variations in the qualitative and quantitative characteristics of each component, and in the relations between components, sub-systems and systems.

In this classification, the two fundamental subsystems which make up the dry forest system consist of biophysical factors and farm families. For reasons of comprehensibility and space, our diagram simplifies this human subsystem to some extent. In reality, there are many groups of people other than 'farm families' present in, and affecting or affected by, the dry forest system, including for example those involved in service activities, commerce and public administration, who may not necessarily actually reside within the dry forest.

The next subsystem described consists of the societal factors which govern the relationships between farm families and biophysical factors. The position of this subsystem within our systems map, above the first two subsystems, reflects

this hierarchical relationship. In turn, the last subsystem, made up of structural factors (policies, markets and institutions) in turn determines both how farm families and biophysical factors interact, and how societal factors affect those interactions; it is therefore placed at the top of the diagram.

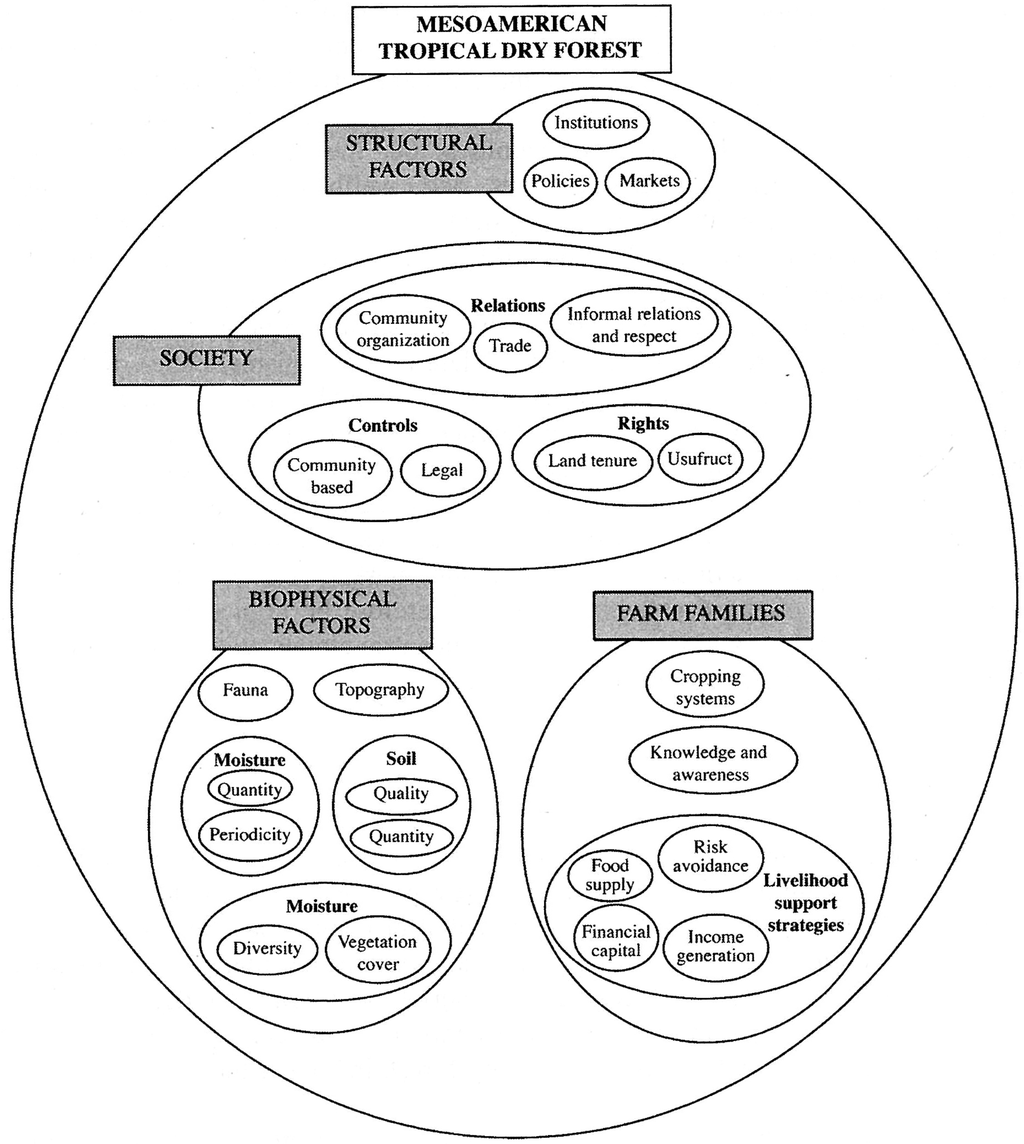

Figure 3.3 Functional components of the MTDF

In our functional systems diagram (Figure 3.3) we choose for pragmatic reasons to separate biophysical, farm family, societal and structural factors into discrete subsystems. In fact, these distinctions are of questionable relevance given

the high degree of overlap and interdependence between the subsystems and their component factors. In particular, it is clear from the results of our analysis that very close relationships exist between humans and their biophysical environment in the dry forest. The examples presented here show how, in both study areas, rural livelihoods are vulnerable to imbalances in the availability of human, social and financial, as well as natural and physical capital. Also significant is the mutual nature of the relationships between humans and biophysical factors in dry forest landscapes. On the one hand, the landscape is the product of human activity. This is true even in the case of the extensive mature and relatively undisturbed forests of southern Oaxaca, whose continued existence largely depends on decisions and controls implemented by local communities. On the other hand, present day demographic patterns, human activities and wellbeing levels are strongly dependent on the conditions of biophysical resources. In keeping with 'anti-essentialist' thinking (see e.g. Escobar, 1999), therefore, man in the dry forest is very much part of nature.

The divisions between the farm family, societal and structural subsystems are if anything even more tenuous. All three relate to mechanisms, codes of conduct and 'rules of the game' which affect relations between humans, and between humans and their environment. The difference between them is one of scale and hierarchical level; societal factors happen more locally in the landscape whereas many structural factors, despite being portrayed in the diagram inside the dry forest system, operate or originate outside of the landscape. Examples are nationally formulated policies, national institutions, and markets for products which are exported outside of the dry forest. It could therefore be argued that these three subsystems should instead be portrayed as concentric circles, with farm families at the centre and structural factors at the outside.

Trends in the MTDF

Having taken a 'snapshot' of the hierarchically arranged components of the MTDF, we go on to examine whether, and how, key parameters of the landscapes are changing. This helps to identify where potential problems may lie and, therefore, where interventions should focus. Based on a review of the literature on historical and archaeological evidence, comparative aerial photograph study, analysis of census data and community level socioeconomic research, we can identify a number of trends which have affected the dry forest, including the following:

1. Expansion of the area used for agriculture, dating from pre-Colombian times. As pre-Colombian population grew and accreted into larger settlements and cities, there was permanent clearance of areas around urban areas and increasing pressure from cyclical slash and burn agriculture, coupled with increasing extraction of game, timber and other forest products (Newson, 1992; Rodríguez Canto, 1995).

2. Establishment of colonial era cattle ranches on flat lands and hills, and monocultures on flat lands, leading to the marginalization of small farmers onto hill lands.
3. Exponential population growth and reduction in farm size on hill lands, due to a combination of push factors (e.g. commercial agriculture on the flat lands which has marginalized small farmers onto the hills), pull factors (e.g. mining industry and demand for basic grains, the economic opportunities offered by which have attracted population to the hills) and reproductive growth (DGECH, 1993; Stonich, 1993).
4. Mid 20th century booms in export crops such as melons, sugar cane and cotton, and cattle.
5. Late 20th century agrarian reform leading to clearance of lowland forest (e.g. secondary forest on outliers in coastal plains) in order to demonstrate occupancy.
6. Increased enclosure of communal lands in Mexico.
7. Population emigration from the hill lands due to unsustainability of livelihoods (linked to natural resource degradation), leading to scarcity of labour for resource management.
8. Intensification of tree management in some areas, using low labour requirement practices, in response to scarcity of tree products.
9. Increased use of extensive land management practices in others due to labour scarcity
10. Relaxing of species selection criteria in response to scarcity
11. Slump in coffee prices leading to abandonment of estates and loss of natural shade areas.
12. Slump in beef markets leading to abandonment of ranches.

Processes and Interrelations

The trends presented above are the cumulative result of multiple interactions between the subsystems and components which make up the dry forest landscape systems. To be able to influence these trends, it is necessary to go beyond a simple identification and hierarchical ordering of components, and to examine cause-and-effect relationships. The number of such relationships is vast; therefore, for the sake of brevity and clarity, below we concentrate on the 'cyclical steep land agroecosystem', with particular emphasis on the theme of how local people interact with trees and forests, and we structure our analysis around the functional subsystems identified in the previous section.

Biophysical factors

The most fundamental determinants of the landscape are the factors listed within the biophysical sub-system. The availability of moisture, in particular, is a crucial determinant of the characteristics of the area's flora and its productive potential. More important than the total quantity of moisture is its seasonality; the

pronounced dry season which characterizes the dry forest zone has favoured the development of tree species which are particularly tolerant to water stress. There are also strong interdependences between the flora and fauna; many trees depend on pollination by insects, resulting in the development of gaudy flower displays during the dry season by tree species such as *Tabebuia chrysantha* and *Cochlospermum vitifolium*, or by bats, as in the case of *Bombacopsis quinata*; a number of species are dependent on seed dispersal by fauna, such as *Enterolobium cyclocarpum* and *Samanea saman.*

The strong seasonality of the rainfall has influence outside of the biophysical sub-system itself, as it places severe constraints on the range of crops which farmers can produce. Crops are dominated by maize (*Zea mays* L.) and beans (*Phaseolus vulgaris* L.), the lengths of whose cropping periods coincide closely with the duration of the two main periods of rain which typically make up the wet season; and also *maicillo* (*Sorghum bicolor*) whose cropping period occupies the whole of the wet season and which is much more resistant to variations in rainfall patterns than the other crops. Another biophysical factor which imposes significant constraints on productive options is topography; this limits farmers' market access and also the practicality of intensifying agriculture through the introduction of mechanized cultivation or irrigation. Conversely, the dominance of the flora by nitrogen-fixing leguminous species facilitates the recovery of soil fertility during fallow periods.

Farm families

Various factors within the farm family sub-system in turn have feedback effects on the bio-physical sub-system. Farmers' cropping systems on the hills rarely involve the removal of tree stumps or the application of the quantities of fertilizer required to permit continuous cropping, as topographical and agronomic constraints tend to make such intensification economically unattractive and/or impractical. This permits the survival of large quantities of live tree material in the agricultural landscape, in the form of stumps, seeds and seedlings; these are periodically able to develop into trees and shrubs, often reaching reproductive age, in the fallow periods on which farmers depend to allow the soil to recover fertility. Conversely, the typically low productivity of these crops per unit area means that virtually all of the dry forest landscape over much of the Pacific drainage of Central America has been converted to cropping or fallow; while low crop value also makes it attractive to farmers to use land clearance practices with low labour demands, such as burning. As a result, the agroecosystem is dominated by those species able to withstand high levels of disturbance and to regenerate in fallows. Typically these species have rapid growth rates, strong coppicing ability (even after burning), and abundant, wind- or animal-dispersed and durable seeds.

Factors within the farm family sub-system also affect other components of the biophysical sub-system, including moisture and soil. With some exceptions, such as the mulch-based *tapado* systems used in some areas (Meléndez *et al.*, 1999), farmers typically endeavour to maintain their crops free of weeds and other non-crop plant material. This leads to high rates of evaporation of soil moisture; surface crusting due to rainfall impact, which in turn reduces rainfall infiltration

rates; and soil erosion due to cross-surface flow (Hellin 1999). These forms of degradation feed back once again into the farm family sub-system, as moisture and soil are fundamental components of the natural capital on which smallholder agriculture depends. It is important to distinguish which aspects of these factors are critical for production; the availability of moisture during dry periods is more critical than annual averages, while the structure, humidity and fertility of soil are more critical, at least in the short term, than its depth.

How farm families relate to the biophysical sub-system, and the resulting characteristics and sustainability of their cropping systems, depend in turn on other elements of the farm family sub-system. At an individual level, their decisions are taken within the context of their overall livelihood support strategies, which typically seek to combine food production with income generation, to minimize risk and to protect and develop the different forms of capital on which their livelihoods depend. The importance of ensuring adequate food supply leads many farmers to cultivate basic grains even when crop production is limited and unpredictable, financial profitability is questionable and alternative income sources are available; the maize field represents a fall-back option when the availability of money to buy food is limited by slumps in cash crop prices or by difficulty in obtaining paid employment. Conversely, the maize field alone is not enough to sustain livelihoods in the face of needs for cash to meet expenses such as school and medical bills; hence, when they can, farmers typically seek off-farm work, grow cash crops or raise cattle in order to generate income.

Farmers' motivations or abilities to protect the natural capital on which their livelihoods depend are also determined (subject to the constraints imposed directly or indirectly by their biophysical environment) by their individual knowledge and awareness (an aspect of their 'human capital'). This includes factors such as their knowledge of technological alternatives for natural resource management; their educational level, which affects their access to technologies and their ability to take sound resource management decisions; and their appreciation of the non-material or non-immediate values of natural resources.

Perceptions of scarcity of components of the biophysical sub-system may have a direct negative feedback effect on farmers' interactions with that sub-system. An example is the practice of some farmers in the dry forest zone of protecting trees in fields in response to a scarcity of off-field tree products (Barrance *et al.*, 2003). This depends, however, on how important trees are to farmers' livelihoods; for example there was little evidence in the Oaxaca study community of El Sanjón of farmers protecting trees in fields, as they had good opportunities for generating income (from the sale of lemons and from off-farm employment) which allowed them to meet their construction requirements from purchased materials rather than tree products. It also depends on the opportunity cost of protecting trees; another reason few farmers in El Sanjón did so was that their land was well suited for lemon plantations, and had good market access; any other trees protected on their land would displace lemon trees. In most of the other situations studied, the only alternative use for the land was low value staple grains.

The farm family subsystem, and as a consequence the biophysical subsystem which it affects, have been and continue to be characterized by high levels of

instability. Demographic growth among the rural population has led to the almost complete eradication of the original forest cover over most of the Central American dry zone. Subsequently, it has led to the progressive reduction of farm sizes, and also reductions in the length of fallow periods and in the overall area of fallow within the landscape. This situation may affect the tree component of the biophysical subsystem, by limiting opportunities for the regeneration of dry forest tree species in fallow areas. Reductions in fallow periods also limit the ability of the soil to recover fertility between cropping periods, thereby affecting crop productivity and requiring increased inputs of fertilizers. The evidence of farmers nurturing naturally regenerated trees in their fields (Barrance *et al.*, 2003), in an apparent response to increasing scarcity of trees in the shrinking areas of woodland and fallow, suggests that the effects of demographic growth on the biophysical sub-system may to some extent be self-limiting. This would correspond with the findings of other researchers (e.g. Tiffen *et al.*, 1994) who have questioned the link between demography and environmental degradation; however in this situation further study is required in order to assess the significance of increasing trends towards non-shifting agriculture with reduced proportions of fallows, relative to the measures taken by farmers to intensify management in response to change, or to shift to non-agricultural activities.

Another phenomenon which might suggest that processes within the demographic sub-system may be self-limiting is the process of rural-urban migration, from areas where natural resources are no longer able to support further pressure. While municipal level census data in southern Honduras do not show net reductions in populations, this may be partly due to migrations occurring, at least initially, within municipalities, from scattered rural communities to small urban centres. People who migrate from rural to urban areas often send back remittances to their relatives who remain; in some cases these remittances can come to have a very significant positive impact on rural economies and may serve to reduce the dependence of the local population on the exploitation of natural resources. However, in the same way that increasing populations may not necessarily lead to increasing resource degradation, it is not necessarily the case that decreasing populations will lead to decreased pressure. Those most likely to emigrate are the more economically active members of the population, a situation which typically leads to labour shortages and makes it increasingly attractive to apply extensive, often damaging practices for land management, such as burning.

The interactions between farmers and natural resources in the dry forest system are also affected by the status of biophysical factors outside of the geographical limits of the system itself. Increasing environmental degradation and the resulting fragility of livelihoods in the central valleys of Oaxaca, for example, led to migration, particularly in the middle of the 20th century to the then largely unoccupied coastal strip, within the dry forest zone. Conversely, perceptions among the rural population of the dry zone of the existence of better opportunities for livelihood support elsewhere have led many people, typically the most economically active members of the population, to emigrate. These 'promised lands' include urban centres, the United States and, particularly for the population of southern Honduras, the humid zone agricultural frontier of the north coast.

Society

Factors within the society sub-system affect how individuals interact with biophysical factors. At the local level, farmers' decisions on which crops to grow depend partly on trade relations, which determine the opportunities available for selling them. Such relations also have some effect on farmers' decisions regarding tree management, particularly in the case of fruit trees but also, to some extent, timber species; some farmers sell posts and timber from naturally regenerated trees to other members of their communities, and trees may become an important cash crop in communities near to towns with woodworking industries, such as El Triunfo in southern Honduras.

Investment by farmers in natural capital, whether it be through soil conservation or the nurturing of trees in fields as a potential source of products for consumption and sale, is dependent not only on their perceptions of the need to do so, but also on their sense of security that they will not be deprived of the fruits of their labours by the actions of others. This security is achieved by agreements between the members of society regarding their respective rights to land, trees or other components of the environment. This may in some cases be substantiated through the provision of legal titles; however in much of the Central American dry zone informal recognition of tenure and usufruct rights is as effective in practice as formal tenure.

Relationships between individuals at community level are particularly highly developed in parts of the dry zone of southern Mexico where land tenure is largely communal in nature. Structures (*comisariados*) exist at community level to protect and administer the communities' natural resources, and decisions on natural resource management and individuals' usufruct rights are taken in community assemblies. This situation facilitates the protection of aspects of the environment which are important to the community as a whole, or for which responsibility cannot be entrusted to individuals ('public goods'). Community level controls on the acceptance of new members have also served to mitigate the magnitude and significance of demographic pressures, arising from the immigration to the coastal strip of people displaced by livelihood failures in the central valleys of Oaxaca.

Elsewhere (for example in Central America), the protection of such public goods is sought by means of legal regulation; however, typically this is ineffective due to the limited recognition in the regulation of the peculiarities of the different components which make up the dry forest system, and the limited resources assigned to those responsible for enforcement. It should be noted that the effectiveness of the community level structures and controls described in southern Mexico are also under threat, as a result of increasingly individual *de facto* tenure and decision making.

Structural factors (policies, institutions and markets)

The policies of both national governments and external agencies have had major effects on rural families, and how they interact with the biophysical aspects of the dry forest system. The most obvious example of this relationship was the

colonization policy of the Spanish Government from the 15th and 16th centuries, which led to a demographic crash of staggering proportions in Honduras (Newson, 1992) and the rest of Central America, and, to a somewhat lesser extent, Mexico (Rodríguez Canto, 1995). This colonization process had two contradictory implications for the condition of the vegetation; on the one hand, the demographic crash allowed the reversion of some areas of land previously cultivated by pre-Colombian populations to second-growth forest, while on the other the imposition of the colonial economic system led to the clearance of lowland forests for the establishment of agricultural export crops (Myers and Tucker, 1987) and, for the first time, cattle ranching. The earliest such crops, indigo and cochineal, had little impact on the vegetation as they were intercropped with subsistence foods; sugar cane, by contrast, required extensive areas for cultivation and large amounts of fuelwood for processing and so had much more significant impacts (Myers and Tucker 1987). Policy support for such export agriculture has continued into post-colonial times, for example with the support of the US-sponsored Alliance for Change in the 1950s and the introduction of successive other crops, such as cotton and melons. In addition to causing deforestation of the lowlands, such export agriculture has led to the marginalization of human populations onto the surrounding hills, exacerbating the pressures on the natural resources there.

In parts of the dry zone of coastal Oaxaca, meanwhile, the Government provided machinery in the 1960s and 1970s to clear areas of dry forest for agriculture, while Government support to the development of a tourism complex in the Bahías de Huatulco, Oaxaca, has placed severe pressures on globally important coastal dry forest (Gordon *et al.*, 2003).

Fluctuations in markets and prices for products have also had significant effects on land use and demography. Recent depressions in the price of coffee have led to the abandonment and subsequent clearance of shade coffee plantations in southern Honduras, near to the Nicaraguan border, resulting in the loss of large numbers of mature dry forest trees and habitat for dry forest fauna. Cattle ranching, meanwhile, grew in importance in the 1960s and 1970s, to supply increasing US demand in the face of increases in the price of domestically produced beef (Myers and Tucker, 1987); however in the 1980s a drop in beef consumption led to a slump in demand and a reduction in the Central American cattle herd. The implications of this for the conservation status of dry forest were the opposite of the slump in coffee prices; in Costa Rica, for example, the reduction in ranching facilitated the establishment of protected areas such as the Guanacaste Conservation Area (Janzen, 1986). The export crops which have, since colonial times, dominated the lowlands of southern Honduras have likewise been subject to repeated 'boom and bust' cycles, due to both market and agronomic factors; for example demand for natural indigo declined following the emergence of artificial substitutes, while cotton production eventually ceased to be profitable due to the excessive build up of pests. However these failures have not permitted the re-establishment of dry forest on the coastal plains of southern Honduras as one crop has tended to be followed by the emergence of another (cotton, for example, was succeeded by melons).

Agrarian reform policies have had varying effects. The reforms introduced in Mexico following the Revolution resulted in the establishment of agrarian communities and *ejidos*, leading in many cases to the clearance of forest areas for agriculture. However they also permitted the establishment of structures for community-based natural resource management, which have proved effective in protecting many forest areas against external and internal pressures. The agrarian reforms of the 1960s and 1970s in Honduras likewise led to the clearance of forest, as farmers were obliged to demonstrate that land was under active use to avoid risking it being expropriated. In contrast to Mexico, however, this was not accompanied by a strengthening of social capital and many of the farmer groups and cooperatives which initially benefited from the reforms subsequently broke up and sold their lands; tenure and natural resource management in Honduras remain predominantly individual in nature.

The institutional context in Honduras, related to the regulation and orientation of the interactions between the rural population and the natural resources of the dry forest, is characterized by limited technical and physical capacity and a high degree of centralization. As a result, regulations tend to be inconsistently applied and to provide a disincentive to the sustainable management of trees by local people; while technical support typically fails to address the most important issues in the most appropriate manner. An example is the emphasis placed by many development organizations on limiting soil loss, instead of the loss of soil moisture, which is a more critical limiting factor for crop production in the short term; and on the establishment of tree nurseries and the use of planted stock, despite farmers' limited labour availability and the abundance of natural regeneration.

Weaknesses among federal institutions in Mexico are to some extent compensated by the existence of institutions and other structures at State, municipal and community levels. However a negative implication of this institutional multiplicity is the competition that exists between these different levels. Some State level authorities, for example, seek increased influence and autonomy from federal entities; while some agrarian authorities at community level have come to mistrust the initiatives of federal entities, due to concerns about the rights to their natural resources being undermined. An example in the dry zone of Oaxaca was the expropriation of lands belonging to the Santa María Huatulco agrarian community, by the federal tourism foundation FONATUR, for the establishment of the Bahías de Huatulco tourism complex; this led to significant resistance to the subsequent proposal to establish a federal reserve on part of the land expropriated from the community.

Loops and Spirals

In the analysis presented above, not all of the cause-effect relationships were linear. In a number of cases, self-limiting 'negative feedback' loops emerged, in which a change in a given parameter leads to a reaction which tends to reverse that change. There were also self-perpetuating 'positive feedback' spirals in which a change in

one factor triggers a change in another which further aggravates the first. Negative feedback tends to perpetuate stability; positive feedback leads to change. As we will see below, these loops and spirals are significant determinants of the social and biophysical conditions of dry forest landscapes. We pay special attention to them here as they tend to present greater problems for the decision-maker than straightforward linear relationships. Given the complex nature of the cause-effect relationships in a landscape, we focus on only a few relationships which we consider to be both important and subject to influence.

Poverty and land degradation

Figure 3.4 presents in graphical form a simplified version of the situation facing many smallholders on the hills of southern Honduras. At the centre, enclosed by a dotted circle, are a number of interrelated positive feedback spirals or 'vicious circles' in which poverty and land degradation are mutually perpetuating. Under conditions of low and irregular rainfall, small farmers only produce low yields of low income value crops, and are therefore unable to accumulate the financial capital required to invest in increasing yields. Low income levels also lead to emigration, resulting in labour scarcity which contributes to the difficulty of investing in intensification, including the labour-intensive forms of soil conservation promoted by extension organizations. This leads to degradation of soil resources which further limits yields.

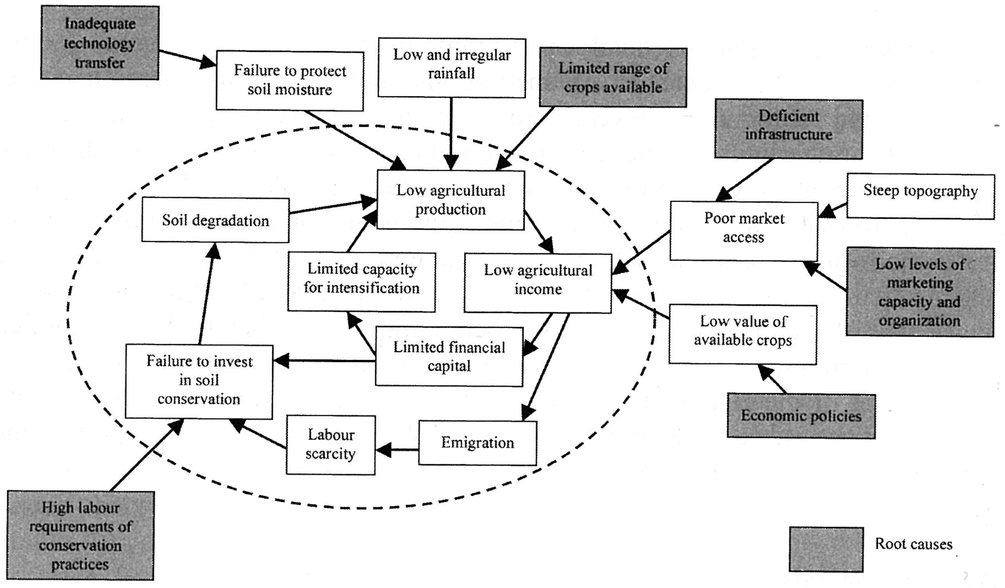

Figure 3.4 Vicious circle of poverty and land degradation affecting staple grain producers on the southern Honduran hills

Fallow elimination and on-farm tree management

Figure 3.5 depicts a self-limiting negative feedback loop in which the scarcity of tree products faced by farmers in southern Honduras, due to increasing population levels, the resulting progressive sub-division of farms and the elimination of fallows and woodlands, leads many of them to protect naturally regenerated trees within their fields, thereby limiting further increases in scarcity. Typically, farmers carry out this practice when they are confident in their rights eventually to use the trees which they protect; when the crops which they produce are of sufficiently low value that tree production does not imply a significant opportunity cost of the land; and when, having limited capacity to purchase alternative building and fencing materials, their livelihoods depend on their ability to produce or gather adequate supplies of tree products.

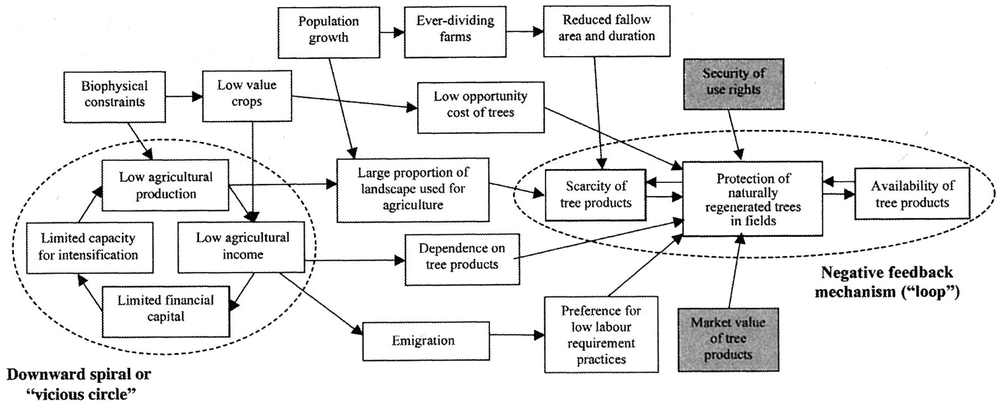

Figure 3.5 Cause and effect mechanisms affecting protection of trees in fields by farmers in southern Honduras

This practice of protecting trees in fields was not observed in the study communities in Oaxaca, confirming the validity of the cause-effect relationships depicted in Figure 3.5. In most of the communities, income levels (and therefore opportunities to purchase alternatives) were low, as were crop values (and therefore the opportunity cost of the land). However, relatively low population levels and a corresponding relative abundance of tree products in fallows and woodlands removed the motivation to protect trees in fields. Neither was on-farm tree protection evident in the one Oaxaca community (El Sanjón) where woodlands and fallows were scarce. Here, favourable topography and access to markets opened up opportunities for profitable cash crops (lemons), thereby increasing the opportunity cost of the land; ready access to sources of cash income from off-farm employment and the sale of lemons allowed families to purchase their building and fencing materials; and the lemon plantations themselves provided a source of fuelwood.

Individualization of land management and resource mining

Figure 3.6 is a very simplified depiction of a positive feedback spiral evident in some of the communities studied in Oaxaca, Mexico. Partly as a result of Government policies aimed at modernizing agrarian structures and agricultural production, there is an increasing tendency towards individual management of natural resources, based on individual claims of rights to resource tenure and use. This is evident in the extensive areas of communal lands in many communities which are fenced off for individual use. This increasing individuality tends to reduce the importance to farmers of community-based decision making and regulation; community regulations tend to apply much more to how communally-held resources are managed, and have little influence on what goes on in the plots 'belonging' to individual farmers. Weakened regulation in turn makes it increasingly easy for farmers to fence off communal lands at will. *De facto* individual tenure also leads farmers to take 'public goods' less into account in their resource management decisions; rather, they tend to aim for the balance between resource use and conservation which best meets their personal needs. The logical result, especially in situations where community-based regulation is being eroded, is a reduction in forest cover beyond the level which the community as a whole would normally aim for, were it to take public goods into account.

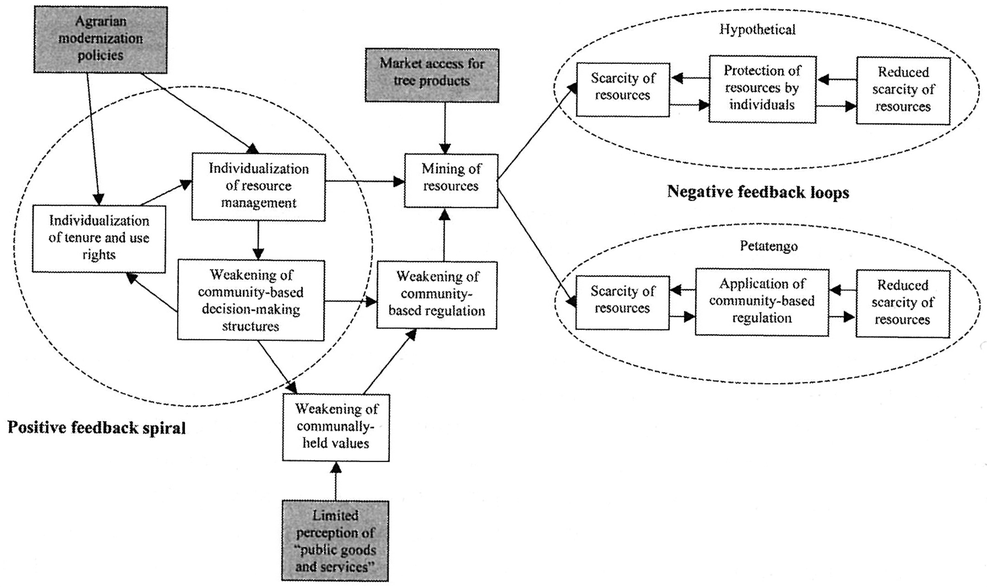

Figure 3.6 Mechanism of natural resource privatization in coastal Oaxaca

In the study community of El Sanjón, this tendency has led to the almost complete elimination of woodlands and fallows. In this case, however, the self-perpetuating spiral of individualization, weakening of social capital and

deforestation has 'bottomed out', now that virtually all land is individually held and almost no woodlands or fallows remain. In the other Oaxacan study communities, conditions of poverty and low opportunity cost of the land are similar to those which, in Honduras, have resulted in an eventual negative feedback loop when scarcity of tree products has reached sufficient levels. However, given the relative abundance of tree products still available in these communities, it remains to be seen whether such a self-limiting loop will eventually come into operation here, with farmers modifying their individual behaviour to avoid scarcity as they have in much of southern Honduras.

The study community of Petatengo demonstrates that foresight and strong community action can check the downward spiral before it reaches the levels of scarcity where individual negative feedback loops came into play. Here, community members recognized that the enclosure of land by individuals, typically better off people who had resources to invest in fencing the land, was marginalizing poorer people to the less fertile lands further from the village centre. The community assembly therefore introduced a negative feedback mechanism, through the passing of regulations prohibiting further enclosures (Figure 3.6).

Entry Points for Interventions

In situations where the wellbeing of the human population or the condition of the natural resources of the dry forest system are at low levels or in decline, policy interventions can help to improve these conditions. These can act by breaking negative feedback loops which, for example, trap farmers in conditions of poverty, and downward spirals which lead to their conditions progressively worsening; or they can focus on strengthening loops which promote the stability of desirable parameters and on upward spirals which lead to their increase.

In order to affect these loops and spirals it is necessary to seek 'entry points' which affect the balance between their constituent elements. With this objective, let us revisit the examples presented above. In the first case, that of the staple grain producers in southern Honduras (Figure 3.4), the vicious circle of poverty and land degradation is not entirely closed, but rather a number of linear cause-effect chains feed into it at different points. The shaded boxes at the beginnings of these chains represent potential entry points. Low and unreliable agricultural productivity, for example, is due not only to soil degradation but to poor moisture management; a situation which could be addressed, even under conditions of labour shortage, by the development and promotion of mulch systems such as *frijol tapado*, whose potential has been amply demonstrated in Costa Rica (Meléndez *et al.*, 1999) and is already in use in some parts of southern Honduras. The resulting improved production could in turn allow farmers to generate surpluses of production which could be sold, enabling them to accumulate the capital required to establish more profitable crops and invest more in soil and water conservation, while at the same time reducing the motivation to emigrate; this in turn would reduce the labour shortages which also currently present a barrier to intensification and soil conservation. In this way, a self-perpetuating downward spiral may be transformed

into a self-limiting loop or even a self-perpetuating upward spiral. The other entry points identified (the shaded boxes) could be addressed by, in clockwise order, introducing alternative drought resistant crops; improving infrastructure; training farmers in organization and marketing; modifying economic policies to increase the prices farmers can obtain for their products; and developing soil conservation practices with low labour requirements.

Some factors, such as the unpredictability of climatic patterns or the steepness of the topography, may be immune to direct feedback through management interventions. The most that can be done in such cases is to influence the systems which allow farmers to cope with these factors, for example by developing and promoting technologies which buffer climatic variations, or investing in access and transport.

By contrast, in the second example (Figure 3.5) what is sought is the strengthening of the negative feedback mechanism which ensures farmers' continued access to tree products. This could be achieved by modifying legislation and developing local social capital in order to strengthen farmers' security regarding their use rights to trees; and by increasing the market value of trees by, for example, promoting markets for lesser known species. There are a number of other entry points into the mechanism evident in the diagram; however these represent reasons why the negative feedback mechanism is necessary, rather than prerequisites for it to function. It is important to recall that the system is not an end in itself, therefore it would not be justifiable to, for example, deny farmers access to higher value crops in order to keep the opportunity cost of the land low, in order to ensure that they continue to protect trees. Rather, the most desirable outcome would be for the mechanism to become unnecessary, for example by successfully breaking the vicious circle (at the left of the diagram) which keeps farmers trapped in poverty and indirectly makes it necessary for them to protect trees in fields.

In the third example, from Oaxaca (Figure 3.6), resource mining resulting from a positive feedback spiral of weakened social capital and increased individualism could be addressed by strengthening communities' awareness of public goods and services which could arise from improved regulation and communal decision making; by promoting the development of markets to enable communities to internalize the benefits from such goods and services; and by modifying agrarian policies and legislation which indirectly lead to the breakdown of communal social capital.

Limitations of the Analyses

The different approaches to analysis presented above help to untangle the complexity of the MTDF. Scale and interchangeability are useful pragmatic criteria for an initial classification of MTDF landscapes; while analyses of function, processes, interrelations and trends allow the identification of the potential implications of interventions. However each of these approaches has limitations, which must be taken into account when applying them.

Subjectivity

To understand how the components of the landscape relate to each other, we have used a set of separate diagrams for specific sets of relationships, focusing on particular themes, and eliminating relationships which do not appear relevant or significant. This simplification is necessary in order to reduce complexity to manageable levels. However it should be noted that this process implies a degree of subjectivity and risks overlooking relationships whose importance is not obvious at first glance. In this chapter, we have chosen to focus on those factors and components which are of relevance to the subject of our research, namely how the vegetation (specifically the woody elements of the flora) is managed and conserved by the local population. Specialists from other disciplines might take different approaches. A zoologist, for example, might balk at lumping outlier woodlands in the MTDF lowlands, which provide important habitat for fauna, into the same landscape as the relatively sterile melon fields which surround them, in contrast to a tree population biologist who would recognize the importance of the gene flow between trees such as *Bombacopsis quinata* in the woodlands and the scattered individuals found in the surrounding pastures and fencelines (Boshier *et al.*, 2004). An ecologist, meanwhile, might insist on an alternative subdivision of the Oaxacan dry forest into categories such as low deciduous forest and medium sub-deciduous forest, *sensu* Rzedowski (1981).

Subjectivity is a consideration not only in deciding criteria for classifying components of the MTDF landscape but, more importantly, in defining what outcomes are desirable in the MTDF and therefore what interventions should be undertaken to achieve them. It might, for example, be understood from some of our earlier discussion that stability of biophysical and socioeconomic conditions is a desirable state of affairs, and that actions should therefore be taken at those 'entry points' which serve to strengthen negative feedback loops and weaken positive feedback loops. Change, however, is not necessarily bad, for example when income levels are increasing or deforestation rates are decreasing; nor is stability necessarily good, for example when it implies rural communities being trapped in conditions of underdevelopment. The decision as to which trends (change or stability) are negative or positive, meanwhile, depends to some extent on the perspective and priorities of the viewer.

Porosity and overlap

The examples presented in this chapter also show that the boundaries defined in the analyses, both external and internal, are to some extent artificial. Each of the landscapes described, and indeed the dry forest as a whole, is heavily influenced by factors outside of their boundaries. Examples include the displacement of population from the lowland landscape to the steep land agro-ecosystem of southern Honduras due to the expansion of lowland commercial agriculture; immigration into the steep land agroecosystem of Oaxaca due to livelihood failures in areas located outside of the study area; and deforestation of wooded outliers in the Honduran lowlands due to agrarian reform policies formulated at a national

level. The boundaries should therefore be regarded merely as pragmatic necessities, required for the purposes of organizing and discussing the systems, rather than real features. The boundary of the dry forest system as a whole can, again for the sake of convenience, be regarded as coinciding with the geographical boundaries of the ecosystems or life zones (*sensu* Holdridge, 1987) that make it up; although again, this system is not sealed.

Implications for Practitioners and Policy Makers

The types of analyses presented above provide practitioners and policy makers with tools with which to identify the causal relationships which affect, either positively or negatively, socioeconomic and biophysical conditions in the MTDF landscape. Most significantly, they allow the identification of 'entry points' for interventions, aimed at achieving desired sets of outcomes; this approach is especially useful in the case of those cause and effect relationships which are circular in nature and may therefore appear at first sight to be intractable.

In using the analytical processes which we present here as a tool to assist decision-making, it is necessary first to define and prioritize the outcomes which are sought and to focus on those aspects which are relevant to those outcomes. Only in this way will the complexity of the analysis be reduced to manageable levels. It is vital to take into account, however, that these priorities may not coincide with those of other interest groups. Where these priorities, or the actions required to achieve them, conflict with those defined by other stakeholders, it may be necessary to seek compromise solutions through processes of joint analysis and negotiation. In the example of individual vs. communal patterns of tenure and resource management in Oaxaca, for example, the ideal situation is a balance: one in which individuals enjoy exclusive use rights to certain plots of land, certain key areas are left under communal management as sources of public goods, and community-based regulation remains strong enough to avoid the actions of individuals affecting the public interest, even on their own land.

In setting priorities for interventions, decision-makers must also take into account considerations of cost-effectiveness. The introduction of a temporal dimension into the analysis, looking at what would be the cumulative implications of the cause-effect relationships in terms of trends in key variables, in the absence of intervention, enables one to identify whether there is a problem or not – for example, is poverty increasing or forest cover decreasing, and can we rely on negative feedback loops to 'kick in' at some point; or is the situation likely to spiral out of control, requiring intervention?

The likely effectiveness of interventions also depends on the distance between the 'entry point' and the desired outcome. This is especially the case when a cause-effect relationship originates outside of a given system. Policies formulated at national or global level, for example, may be influenced relatively little by feedback on their impacts on people's wellbeing or the conservation status of natural resources at local level. By contrast, farmers' actions may be influenced promptly by observations by them of their effects within their farms. In cases

where causes and their effects are widely separated, it may be particularly important to be proactive in promoting the development of negative feedback loops, for example by feeding information on policy impacts back to those responsible for policy formulation.

Conclusions

As shown in this chapter, the MTDF and its constituent landscapes and land units, and the interactions between them, are highly complex. We have shown however that these landscapes can usefully be represented in a simplified manner (on the basis of structure and function) to highlight key entry points for interventions. However, despite the attractiveness of such representations, it should be recognized that the landscape is far from static; there is also a significant degree of 'porosity' and overlap between its components, and the MTDF as a whole is not a sealed entity but rather is subject to influences, such as policies, regulations and market forces, with origins outside of the system. It must also be recognized that the nature and outcomes of these processes of analysis will depend on the priorities of who carries them out; they should be used only as an aid to decision-making, complementing rather than substituting necessary processes of multi-stakeholder analysis and negotiation.

Notes

1 The coastal plains around the Gulf of Fonseca and the foothills of the Pacific drainage, up to an altitude of 800 metres above sea level, in the Departments of Choluteca and Valle.
2 Between the coast and the Sierra Madre del Sur, from the border with Guerrero State in the west as far as, but not including, the Isthmus of Tehuantepec in the east.
3 This publication is an output from a research project funded by the United Kingdom Department for International development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. Project R6913 Forestry Research Programme.

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Chapter Four

Ecosystem Dynamics and Institutional Inertia: A Discussion of Landscape Conservation in Northern Tanzania

Jim Igoe

Introduction: Paradigm and Policy Shifts

From 1994 to 1997 I lived in the East African country of Tanzania conducting dissertation research for a doctoral degree in anthropology from Boston University. During most of my fieldwork I lived in Maasai herding communities in Simanjiro district, on the eastern boundaries of Tarangire National Park. My original research ideas revolved around understanding social change amongst the Maasai by investigating transformations in traditional forms of cattle exchange. The Maasai I interviewed were in the early stages of this project not slow in telling me that this line of enquiry was not very interesting. Most of my respondents were more interested in talking about the issue of land, more specifically the loss of land to outsiders. If I wanted to do something useful, people informed me repeatedly, I should study how they were losing their land and help do something to stop it.

On the basis of these remonstrations I did indeed shift my research topic to the question of land, and especially the role of Maasai leaders in advocating for community land rights. I began with a five village survey, which examined land loss, resource management practices, environmental change, and environmental knowledge. Through this survey I discovered that Maasai communities in my research area had lost land to three primary sources: 1) Tarangire National Park; 2) small scale agriculturalists, who had immigrated to Simanjiro from neighbouring areas; and 3) large-scale commercial farms. Respondents in some communities also complained about losing land to mining interests and tented safari camps. Some also complained that charcoal making had denuded Simanjiro of trees. They believed that this in turn resulted in lowered rainfall.

Of all these sources of land loss I was most intrigued by Tarangire National Park. From an early age I came to believe that parks in East Africa were wildernesses, landscapes uninhabited by human beings. I never questioned how such landscapes might come into being, I simply accepted their existence. I was taken by surprise, therefore, when people in Simanjiro informed me that they had lived in the area that was now Simanjiro National Park as recently as 1971. People claimed that since their removal from the park they had been subject to a variety of

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This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. R6913, Forestry Research Programme.

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Executive summary

This book examines the concept of 'conservation through use' (CTU), using the conservation of tree species diversity in Mesoamerican dry forest in Honduras and Mexico as a case study. It discusses the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods.

Mesoamerican tropical dry forest (MTDF) is an important biome for rare and economically important tree and shrub diversity. It has, however, suffered severe deforestation, largely through clearance for smallholder agriculture and for ranching. The need to conserve this diversity without compromising the already fragile livelihoods of the inhabitants of the region led the UK Government's Department for International Development (DFID) to fund a research project 'Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS) for four years from 1998. The results of that project, based on multidisciplinary research in two case study areas are collated and discussed in this book.

CUBOS aimed, through a combination of botanical and socioeconomic research, to identify effective and sustainable strategies for the conservation of tree species diversity in the MTDF, compatible with local cultural and tenure conditions and the development needs of the local population. Its secondary aim was to contribute to an improved understanding of the conditions under which conservation through use may in general be an effective strategy to conserve endangered species and/or habitats.

Key questions addressed by the research included the following:

- What benefits do farmers obtain from MTDF trees and forests, how do these benefits influence their management decisions and how can they be increased?
- On which MTDF tree species, land uses and sites should conservation efforts be concentrated?
- Under what circumstances is conservation through use an effective strategy to conserve MTDF tree species and ecosystems?

Within the broad field of conservation and development, the study restricted itself to a consideration of tree and shrub species in productive landscapes and focused on determining conservation priorities from a global perspective. It used a rapid botanical survey to define which species and sites in the case study areas are of highest priority for conservation. Unlike much other work, which bases conservation decisions on biodiversity (a measure of numbers of species, regardless of their conservation importance), this study used the concept of bioquality (a measure of the proportion of rare species in the vegetation, weighted by their global rarity).

The research was carried out in two contrasting case study areas chosen to represent conditions in much of the rest of the tropical dry forest zone of Mesoamerica, with the aim

that the information generated and strategies identified in the course of the research should be of relevance throughout the region, and wherever possible beyond.

The first case study area was southern Honduras, which, in common with much of the rest of the Pacific slopes of Central America, is dominated by a highly disturbed dry forest agroecosystem. Here many farmers were found to actively protect trees they valued, particularly for timber. The extent of this conservation through use depended upon a number of factors: the level of demand for the tree's products and services and their availability from off-farm or purchased sources; the degree to which the species concerned tolerates conditions in the agro-ecosystem, and regenerates well; the security which farmers feel over their future rights to reap the benefits from the trees; and the effectiveness and flexibility of regulation.

The second study site of coastal Oaxaca contrasted sharply with southern Honduras, having large areas of apparently intact MTDF and with strong community-based controls on natural resource management existing in some parts of the area. Here conservation through use was found to operate largely at the communal, rather than individual, level, and to affect both forests as a whole and individual tree species. As in southern Honduras, the principal factors which determine the implementation of conservation through use in coastal Oaxaca include the existence of demand and markets for the products of trees and forests; the level of scarcity of the products and services of trees and forests; and the effectiveness of regulation, in this case at the community level.

The botanical survey produced a checklist of tree and shrub species for both sites, assessing their global rarity and indicating the land use types in which they are most likely to be found. The highest levels of bioquality were found in the most intact and largest forest areas of the Oaxaca case study area. Most of the high bioquality forests would be considered small and fragmented by global standards. However many of the agricultural areas which surround them are also of high bioquality, and may be important for maintaining biological connectivity between the forests. Communal organisation, management and control have contributed to conservation in Oaxaca. They have led to activities being zoned and regulated by local communities and benefits being shared between forest users. These systems are, however, under threat from trends towards private land ownership.

Although supporting surprisingly high levels of tree diversity, given the degree of disturbance that it has undergone, the southern Honduran agroecosystem is of relatively low bioquality in terms of tree and shrub species. No patches of high bioquality mature forest remain and most of the species there are widespread, adapted to disturbance and not of global conservation importance.

In both study areas, there is little overlap between those species which farmers value and protect, and those which are most threatened. None of the 108 species mentioned as used by the farmers interviewed in southern Honduras, and only 4 of the 281 mentioned in coastal Oaxaca, are globally rare. Conservation through use at the species level therefore appears to have limited value for biodiversity conservation. CTU at ecosystem level has more potential

because it can lead not only to the conservation of the forest ecosystem as a whole (as we found in Oaxaca) but also, incidentally, of many priority species within the forest.

In order to determine the potential of CTU in any given case and to develop strategies for its promotion, it is important to understand whether the person or people benefiting from the conservation are directly or indirectly responsible for implementing conservation activities, whether CTU is ensured through regulation and/or incentives, and whether species and/or ecosystems are the object of conservation.

Key recommendations from this research include:

- Communities in coastal Oaxaca (and other areas with similar conditions of tenure, organisation and bioquality) should be supported in carrying out CTU in communal forests, where this approach has proved effective in conserving tree and shrub species of high global conservation priority.
- Farmers on the Pacific slopes of Honduras (and other areas with similar production systems and trees with similar characteristics) should be supported in carrying out CTU of naturally-regenerated trees in fields, thus maintaining supplies of tree products of importance for their livelihoods. Given the low numbers of globally rare tree and shrub species in these agroecosystems, this form of CTU should be seen primarily as a rural development issue, rather than one of biodiversity conservation.
- Given that CTU does not necessarily conserve ecosystems in an intact state and may be affected by changes in social and economic conditions, complementary support should continue to be provided to the establishment and management of protected areas, in those parts of the MTDF zone with globally important biodiversity, and where these are socially and politically feasible and likely to be financially sustainable.
- 'Backstopping' strategies should be developed for globally-important species which cannot be conserved effectively through either CTU or in protected areas (due for example to their limited valuation by local people, unfavourable conditions of tenure and community organization, their inability to prosper in disturbed environments or excessive levels of pressure). These strategies may include, for example, *ex situ* conservation.
- Decisions on conservation priorities and strategies elsewhere in the MTDF should be taken on a case-by-case basis, and in an informed and objective manner, based on systematic inventories of the numbers of high conservation species which they contain and investigations into productive, organisational, economic and tenure conditions.

Contents

Acknowledgements iii
Author information iv
Executive summary v
Acronyms and glossary xiii

1. Conservation through use: The debate 1
Aims and objectives 1
The debate on conservation and development 2
The Mesoamerican tropical dry forest as a case study 4
A definition of CTU 5
Underlying assumptions 6

2. The Mesoamerican tropical dry forest in context 9
Where and what is Mesoamerican tropical dry forest? 9
Why is Mesoamerican tropical dry forest (MTDF) important? 9
MTDF at the turn of the Millennium 11
Current threats to MTDF trees and forests 12
The people of the dry forest 14
Poverty in the Mesoamerican dry zone 15
Existing conservation approaches in the MTDF 16
Rural development initiatives related to MTDF trees and forests 19

3. Case study areas and research methods 23
An integrated research approach 23
Study areas 23
Study communities 24
Socioeconomic survey 25
Policy context 28
Botanical survey 28
Feedback and dissemination 30

4. Southern Honduras: Trees managed by and for farmers 31
Trends in land use, forest cover and tree populations 31
Smallholder agriculture today 33
Institutional environment 34
Policy and legislative environment 35
How farmers use trees 36
How farmers perceive trees 39
Species preferences 40
Access to tree products 41
The importance of species diversity 42
How farmers protect and manage trees 43
Conclusions: Key factors affecting how farmers use and conserve trees 46

5. Coastal Oaxaca: Community-based conservation **49**
Historical background 49
Trends in tree and forest resources 50
Smallholder agriculture today 51
Institutional environment 52
Policy and legislative environment 54
How farmers use trees and forests 55
Species preferences 55
Sources of tree products 58
Protection and management of trees and forests 58
Conclusions: Key factors affecting the conservation and use of trees and forests 62

6. Global conservation priorities in the MTDF **65**
Species of conservation concern 65
Location of the priority species 65
Fragmentation, corridors and connectivity 69
Conclusions: Consideration of global conservation priorities 70

7. Assessing the potential of CTU in the MTDF **73**
Forms of CTU 73
Can CTU be relied upon for the conservation of rare tree species? 75
Can CTU contribute to improving livelihoods? 79
Conclusions 81

8. Recommendations for implementing CTU in Mesoamerican tropical dry forest **83**
When to promote CTU 83
How to promote CTU 87
Priorities for action in the case study areas and similar sites 89
Concluding remarks 92

References **95**

Appendices
1. Comparing the conservation importance of different sites using the 'genetic heat index' 101
2. Species of conservation concern found in the Oaxaca study area 103
3. Species of conservation concern found in the Honduran study area 106
4. Checklist of Woody Species found in Oaxacan and Honduran Pacific Coast dry forests 107
5. Guide to key institutions 119
6. Suggested reading 122

Boxes

1.1 Gradient of relationships between conservation and use 5
2.1 Some indicators of poverty in the Mesoamerican dry forest zone 15
2.2 Some important dry forest protected areas in Mesoamerica 17
3.1 The case study communities 26
4.1 Tree uses listed by Honduran farmers, in order of importance 37
4.2 On-farm tree material in Los Coyotes and Agua Zarca, southern Honduras 44
5.1 Commercial extraction and reforestation in communal lands in Petatengo 59
5.2 Communal and federal reserves in Santa María de Huatulco 61
6.1 *Swietenia humilis* – threatened or not? 66
8.1 Improving links between NGOs and herbaria 84

Tables

1.1 Stakeholder interests in the MTDF 7
2.1 Results from a selection of tree-based projects 20
3.1 General characteristics of the study areas 25
3.2 Number of families sampled relative to community size 27
3.3 Key for assigning species to conservation categories 30
4.1 Trends in species use for timber in Los Coyotes, southern Honduras 32
4.2 Annual average economic benefits ($/ha) from trees and crops in Los Coyotes 38
4.3 Species most reported as used for firewood, timber and fence posts in southern Honduras study communities 41
4.4 Proportion (%) of informants in Honduras considering availability of different tree products to be sufficient (Suff.) and insufficient (Insuff.) 42
4.5 Proportion (%) of informants in different wealth categories in Honduras considering availability of tree products to be sufficient (Suff.) or insufficient (Insuff.) 42
4.6 Proportions of single-use and multiple-use species in the Honduran case study communities 43
4.7 Numbers of farmers reporting the active protection of different tree species in their fields in southern Honduras 45
5.1 Species reported to have declined in abundance in the Oaxaca case study communities 51
5.2 Frequency of different agricultural practices in case study communities in coastal Oaxaca 52
5.3 Examples of uses and benefits obtained from trees in coastal Oaxaca 56
5.4 Disadvantages and problems of trees mentioned by farmers in coastal Oaxaca 57
5.5 Species most reported as used for firewood and timber in Oaxaca case study communities 57
5.6 Sources of firewood and timber reported by farmers in Oaxaca case study communities 58
7.1 Species of high global conservation priority that were also reported as being used 75

Figures

2.1 The distribution of Mesoamerican tropical dry forest in the year 2000 10
2.2 Trends in population densities in southern Honduras and the Oaxacan coast of Mexico 15
3.1 Location of case study areas in southern Honduras and the coastal zone of Oaxaca state, Mexico 24
4.1 Schematic representation of a typical cropping cycle in southern Honduras 33
4.2 Relative densities of species (seedlings, stumps and trees) in southern Honduran fields 45
6.1 Numbers of high conservation priority (restricted range) species in the two study areas 66
6.2 Comparing the Genetic Heat Index (GHI) of different land use types in coastal Oaxaca and southern Honduras 68
7.1 Alternative mechanisms of CTU 73

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A. Barrance, pages: 37, 39, 46, 55 and 85
J. Gordon, pages: 1, 9, 16, 23, 31, 44, 49, 50, 65, 67, 73, 74, 79, 83, and 84

Glossary and abbreviations

AFE-COHDEFOR	Honduran State Forestry Authority – Honduran Corporation for Forest Development (replaced by the ICF in 2008)
Campesino	Peasant
CODE	Oaxacan Committee for Ecological Defence
COHAAT	Honduran-German Food for Work Cooperation project
COHASA	Honduran-German Food Security project
CONABIO	National Commission for Biodiversity (Mexico)
CONAFOR	National Forestry Commission (Mexico)
CONANP	National Commission for Protected Areas (Mexico)
CTU	Conservation through use
CUBOS	'Conservation through use of tree species diversity in fragmented Mesoamerican Dry Forest' project
DFID	Department for International Development (UK)
EAP	Pan American Agricultural School in Honduras
Ejidatario	Formal member of an ejido
Ejido	Area of communally managed land provided for in the agrarian reform which followed the Mexican Revolution
FONATUR	National Trust Fund for Tourism Development (Mexico)
GHI	Genetic Heat Index
GTZ	German Agency for Technical Development Cooperation
ICDP	Integrated Conservation and Development Project
ICF	Institute for Forestry Conservation and Development (Honduras) (replaced AFE-COHDEFOR in 2008)
INE	National Ecology Institute (Mexico)
IUCN	International Union for Conservation of Nature
Maicillo	Drought-resistant sorghum variety (Sorghum bicolor)
MBC	Mesoamerican Biological Corridor
Mestizo	Mixed race
MEXU	National Herbarium of Mexico
MTDF	Mesoamerican tropical dry forest
NGO	Non-governmental organisation
NTFP	Non-timber forest product
PRA	Participatory Rural Appraisal
PROCAMPO	Programme of Direct Support to the Countryside (Mexico)
PROCEDE	Programme for Certification of Ejidal Rights and Land Titling
PRONADERS	National Programme for Sustainable Rural Development (Honduras)
SAG	Secretariat of Agriculture and Livestock (Honduras)
SAGARPA	Secretariat of Agriculture, Livestock, Rural Development and Fisheries (Mexico)
SEMARNAT	Secretariat of Environment and Natural Resources, (Mexico)
SERNA	Secretariat of Natural Resources and Environment (Honduras)
SINAPH	National System of Protected Areas (Honduras)
Solar	Homegarden
WWF	Worldwide Fund for Nature

1. Conservation through use: The debate

In this chapter we outline the concept of conservation through use, highlight the key questions to be addressed in this book and provide a brief introduction to the Mesoamerican tropical dry forest zone.

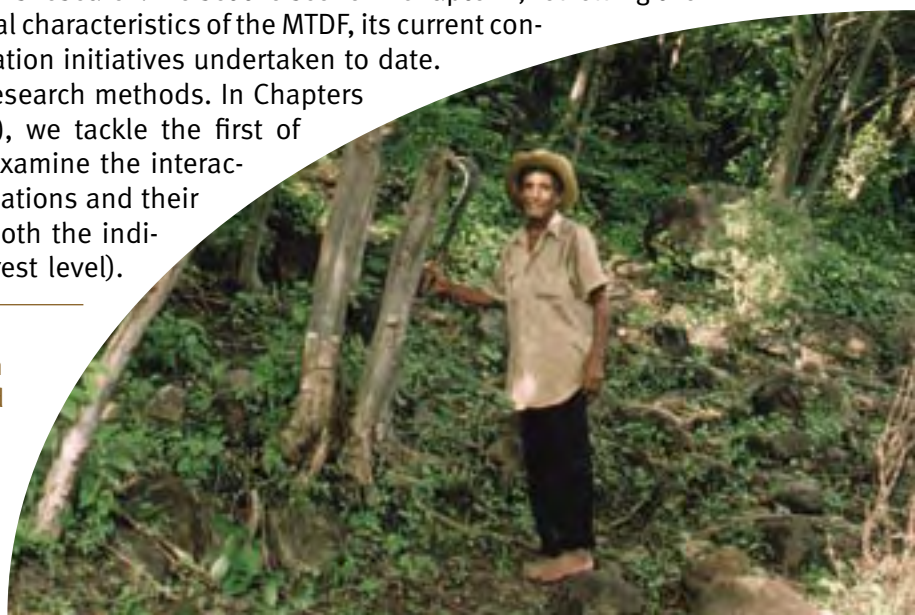
Aims and objectives

In this book we set out to explore the concept of 'conservation through use' (CTU), using the conservation of tree species diversity in Mesoamerican tropical dry forest (MTDF) in Honduras and Mexico as a case study. The background to this work is the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods. To contribute to this endeavour, we ask the following questions:

- What benefits do farmers obtain from MTDF trees and forests, how do these benefits influence their management decisions and how can they be increased?
- On which MTDF tree species and sites should conservation efforts be concentrated?
- Under what circumstances is CTU an effective strategy to conserve MTDF tree species and ecosystems?

To answer these questions, we draw on the results of a four year research project 'Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS), funded by the UK Government's Department for International Development (DFID). This project was jointly implemented by the Oxford University Department of Plant Sciences and the Overseas Development Institute, with support from and in consultation with, a wide range of government and non-government institutions in Honduras and Mexico.[1]

In this introductory chapter, we briefly review the debate on conservation and development and explain why the MTDF is an appropriate case study for examining conservation approaches that also seek to support local livelihoods. We define CTU and highlight some key assumptions underlying this research. We set the scene in Chapter 2, reviewing the socioeconomic and biophysical characteristics of the MTDF, its current conservation status and conservation initiatives undertaken to date. In Chapter 3 we outline our research methods. In Chapters 4 (Honduras) and 5 (Mexico), we tackle the first of our research questions and examine the interactions between the local populations and their tree and shrub diversity (at both the individual tree and the whole forest level).



Regenerating natural forest is important for farmers in southern Honduras as a source of firewood and timber

1. Key institutions active in the MTDF zone are listed in Appendix 5

Our second question relating to conservation priorities is the subject of Chapter 6 in which we present the results of our botanical research, regarding the relative conservation importance of the two case study areas, and of different sites and land uses within each. Our third research question is covered in Chapter 7, in which we take a more detailed look at how CTU works in the MTDF. This is followed by some recommendations in Chapter 8 on how CTU can be implemented more effectively.

The debate on conservation and development

In recent decades, conservationists have come to realise the shortcomings of approaches to conservation based on exclusion and protection (Utting, 1993). In most cases protected areas were established with scant attention to land tenure problems, the development needs of local people or how to finance the high costs of patrolling and protection (Wells and Brandon, 1992). They have also led to severe social impacts through the displacement of native peoples or the curtailment of the productive activities on which those people depend (Brockington and Schmidt-Soltau, 2004). By locking up resources, they commonly represent a significant opportunity cost to developing countries.

In the 1980s, sustainable development emerged as an alternative to earlier protectionist strategies that viewed conservation and development as opposing interests and therefore sought to establish large national parks and other reserves where 'natural' ecosystems could be protected from human influences (Schelhas et al., 2001). An early approach which recognised the compatibility between sustainable use and the conservation of biological diversity was promoted by the Man and Biosphere Programme of the United Nations Environmental, Social and Cultural Organisation (UNESCO). Its flagship biosphere reserves combined protected core zones with surrounding buffer zones in which a wide range of activities was permitted. The term Integrated Conservation and Development Project (ICDP) emerged as a collective label for a new generation of projects that started to go outside park and reserve boundaries and pay particular attention to the welfare of local people (Wells and Brandon, 1992). Some initiatives went further than simply tolerating use, to actively encouraging it on the assumption that if local communities benefited from the resource, they would be motivated to participate in and contribute to efforts to protect it. This constitutes 'conservation through use' (CTU).

In the environmental and development dialogue of the late 1980s, and especially in the 1990s following the United Nations Conference on Conservation and Development in Rio de Janeiro, there was an upsurge of interest in identifying and promoting situations in which CTU might work, where natural resources could be used in ways which would encourage local communities to conserve them and, at the same, would contribute to the social and economic wellbeing of the local people. These included both extractive uses such as non-timber forest products (NTFPs) and non-extractive uses such as the provision of, and payment for, environmental services. Much early work on CTU focused mainly on agricultural crop varieties (Altieri and Merrick, 1987; Cooper et al., 1992; del Amo, 1992a and 1992b; Pimental et al., 1992).

The concept was then widely applied to NTFPs where it was more commonly known as the 'use it or lose it' philosophy (Freese, 1997). Conservation and development organisations alike, particularly those working in the tropical rain forest, promoted the idea that NTFP production and trade had the potential to supply local people with sufficient incomes to provide them with incentives to maintain the forests (Nepstad and Schwartzman, 1992; Ruiz Pérez and Arnold, 1996; Wollenberg and Ingles, 1998). Governments also took an interest with Brazil making a high profile commitment to extractive reserves, where it was hoped that livelihoods based on a combination of rubber tapping and brazil nut harvesting would ensure forest conservation. However, two decades and many NTFP initiatives later, Belcher and Schreckenberg (2007) caution against the optimism still prevailing in some quarters that NTFP commercialisation can be an easy answer to the problem of achieving species and ecosystem conservation at the same time as improving local livelihoods.

CTU also lay at the heart of widespread implementation of community forestry. While early support was motivated by donors' and governments' interests in improving the conservation status of forests, this soon gave way to an interest in community forestry as a route to reducing poverty. This shift in emphasis took place within the context of a global focus on poverty reduction (as illustrated by the Millennium Development Goals and the promotion of national Poverty Reduction Strategies) and the assumption that the very location of many of the world's poorest people in and around forests suggested an important role for forests in poverty alleviation (Hobley, 2006). Community forestry, in which local communities are given varying levels of control over adjoining forests, appeared to be an obvious way to achieve poverty reduction. There is some concern, however, that we have very little idea of the extent to which PFM models developed in different situations have had positive benefits in terms of either biodiversity conservation and/or poverty alleviation (Schreckenberg et al., 2002).

In several areas, therefore, it has become clear that the CTU approach has limitations, and that a number of the basic assumptions on which it depends remain inadequately tested. Some researchers point out that the concept has tended to be used too simplistically, without adequate definition of what aspects of biodiversity were to be conserved (e.g. Redford and Richter, 1999). Others have highlighted the different and often difficult conditions that have to be met, for example in terms of secure tenure, resource inventory and management, producer organisation and market access, for sustainable examples of CTU such as NTFP extraction or community forestry to be feasible.

In parallel with a search for effective approaches to achieve simultaneous conservation and development, there has been growing recognition that it is not possible to create sufficient protected areas to conserve all species (Hutton and Leader-Williams, 2003). It seems that what happens outside protected areas will be as crucial for effective conservation of biodiversity as protection of *in situ* reserves. Most conservation will therefore have to be achieved though co-operation in human social space (Ghimire and Pimbert, 1997). There is thus a strong case for paying greater attention to the role and potential of human-managed ecosystems in fulfilling the goals of biodiversity conservation.

The Mesoamerican tropical dry forest as a case study

There are few ecosystems worldwide where there is more need to reconcile the goals of conservation and development than the Mesoamerican tropical dry forest (MTDF). This ecosystem is of great global importance for conservation: it contains many species with severely restricted natural ranges (Janzen, 1986, 1988; Murphy and Lugo, 1995; Maass, 1995) and Mexican dry forests are classified by the Worldwide Fund for Nature (WWF) as 'critical/endangered' and as one of the Global 200 priority ecoregions worldwide (Olson et al., 2001). Conservation of the MTDF can be considered an international priority both as a unique ecosystem and as a store of genetic variability of proven current value (Gordon et al., 2004). Many tree species originating in the MTDF have been shown to have great potential to contribute to rural development in different parts of the world (see Chapter 2).

The trees and forests of the MTDF are highly important for the livelihoods of local people, as a source of products such as timber, firewood and fruit, and of services such as water supply and soil conservation. These uses have in many cases been linked to the deforestation and degradation of the MTDF ecosystem over much of its natural range, reducing its conservation value at global level and also increasing the vulnerability of local people's livelihood support systems. However, placing tighter restrictions on local people's activities, in order to conserve trees and forests, would risk further compromising their already fragile livelihoods in the short term. There is therefore a clear need for effective and sustainable strategies for resource management, which contribute actively to conservation and, at the same time, are compatible with the immediate needs of the local population.

Tropical dry forests have received very little conservation effort relative to humid tropical forests, in part because of the high economic value of the goods and services that can be extracted from tropical dry forests (Sánchez-Azofeifa et al., 2005). The current very limited and scattered network of dry forest reserves in Mexico and Central America cannot adequately conserve the MTDF. Compared to other regions, the area of tropical dry forest protected in Central America is still disproportionately low (Miles et al., 2006). Furthermore, there is now only limited scope for the establishment of new protected reserves due to the extent of forest loss and fragmentation. The forest-agriculture frontier has long since gone in Central America and been replaced by an intimate and highly localised mosaic of small and vulnerable forest remnants amidst a diffuse matrix of trees outside the forest in even smaller patches of remnant woodland, in traditional agroforestry systems on farms, in fence-rows, homegardens and around settlements (Janzen, 1988).

It seems that the only option for achieving conservation goals over much of the region, therefore, is to incorporate conservation criteria into forest and farm management practices. This makes the MTDF especially interesting as a case study for CTU, because much of its biodiversity exists outside of protected areas, providing an opportunity to study the potential of CTU in productive landscapes. Researchers have also suggested that CTU is already a reality in the MTDF, and that a number of species owe their current conservation status to the fact that local people value their products and therefore nurture and protect them (Hughes, 1998). This may provide an opportunity to learn from and build upon traditional practices.

A definition of CTU

Conservation through use is a term that covers a wide range of situations. Here we define it as *the conservation of any resource, motivated by perceptions of its utility*.

The 'utility' referred to in this definition may result from cash or subsistence benefits which arise from the resource in question (for example through the sale or use of its products) or from non-cash benefits such as the provision of environmental services (for example water or aesthetic enjoyment).

This definition of CTU implies a self-stabilising 'win-win' situation in which the benefits from using a resource lead to its conservation, and this conservation in turn permits the resource to continue providing benefits. It is important to distinguish this situation from other less complementary relationships between conservation and use (Box 1.1).

Box 1.1 Gradient of relationships between conservation and use

1. **Incompatibility**: over-extraction ('Resource mining' in which use is incompatible with conservation, or does not motivate conservation and leads to the resource being actively degraded)

2. **Incompatibility**: strict conservation ('The no-touch approach' in which use is prohibited in order to achieve conservation, as applied in some protected areas)

3. **Compatibility**: neutral interactions ('Conservation with use' in which use presents no problems for conservation, e.g. in the case of enjoyment of the aesthetic value of a landscape or the downstream consumption of water from a protected watershed forest)

4. **Complementarity** ('Conservation through use' in which people's use of a resource leads to their conserving it, which in turn ensures that the resource continues to exist for their use)

As we use it in this book, CTU has two defining features:

- *Its principal aim is conservation*. This distinguishes CTU from other approaches to on-farm tree management, which are primarily concerned with the contribution of trees

to farmers' livelihoods and do not necessarily lead to significant global conservation benefits.

- *It involves positive decisions to conserve resources.* For example, the management of trees on farm, aimed at maintaining a valued native tree resource, qualifies as CTU as it is a positive strategy motivated by the use value of the tree in question; whereas the passive acceptance of non-valued trees on farm is not. CTU is thus associated with the purposeful introduction of agroecosystem components by farmers, or 'planned biodiversity', in contrast to 'unplanned biodiversity' components that colonise without human help (Vandermeer and Perfecto, 1997; Altieri, 1999).

CTU may occur in either intact or disturbed ecosystems, and may be applied either to the ecosystem as a whole (e.g. a forest) or to components of the ecosystem (e.g. individual tree species).

Underlying assumptions

The research approach used to examine the CTU concept was based on a number of underlying assumptions.

There are many objectives for conservation

Different aspects of the MTDF are important to different stakeholders (see Table 1.1), and may require different conservation strategies. Lack of clarity regarding the objectives of conservation has been one of the reasons for its limited effectiveness to date. In this book we focus on the first two stakeholder groups in Table 1.1, comparing the priorities of conservationists and local people in terms of the management and conservation of different sites and species. Different stakeholders have different degrees of power as conservation actors/decision-makers. The key drivers of forest and species loss in some areas may be large landowners and corporations. However, we focus our attention on the conservation actions of small-scale farmers in the two study areas in recognition of the fact that their strong livelihood dependency on natural resource management and consequent vulnerability to poorly conceived conservation strategies makes this a particularly challenging environment in which to develop appropriate conservation solutions.

Conservation priorities can be set at a global level

A critical decision taken in the study was to compare conservation priorities among tree and shrub species (and consequently among the sites where they occur) from a *global* perspective. This is based on the argument that local extinctions (while potentially of great concern for species with important local ecological or livelihood roles) can in theory be reversed through reintroduction or re-establishment, whereas a species that becomes extinct at global level is gone forever. The global value of biodiversity is now widely recognised. This is reflected in the increasing internationalisation of policy formulation, decision making and resource allocation in conservation and is exemplified by policies, mechanisms and institutions such as the United Nations Convention on Biological Diversity, the Global Environment Facility and WWF. This is not to say that national governments may not also have an interest in

setting national-level conservation priorities if the global threat status is not considered to adequately reflect the country's biodiversity conservation needs.

Prioritising sites for conservation requires an assessment of bioquality

The first step in the systematic planning of conservation is to measure and map biodiversity (Margules and Pressey, 2000). However, biodiversity assessments only consider the total numbers of species present, irrespective of their conservation status. In order to prioritise sites for conservation, we assume that it is necessary to go a step further and assess 'bioquality', which takes into account the conservation priorities of the different species found in a given site. The methods used in arriving at an index of bioquality per site are detailed in Chapter 3 and Appendix 1.

Table 1.1 Stakeholder interests in the MTDF

Conservation objective	Stakeholder group	Rationale
Total numbers of species, populations and individuals of flora and fauna	Conservationists and the global public	Wish not to lose species from the planet, because of existence value and/or option value (potential utility)
Adequate quantities of certain valuable species, in appropriate condition (e.g. stem size and tree form)	Local populations	Need for products for subsistence or income generation
Adequate population levels and population diversity of globally useful tree species	Development agencies, small farmers and forest plantation managers	Potential for use in agroforestry systems or plantations elsewhere in the world
Total biomass	Global public	Carbon sink, reducing the risk of impacts on the global climate
Total vegetation cover and structure	People living downstream	Capacity of the forest to regulate stream flows

A focus on trees is valid from both a conservation and a livelihoods perspective

This book focuses specifically on trees in the MTDF. This is because they are of fundamental importance to local people's livelihoods, as well as having a very high global 'use value'. As targets for conservation they are also more easily managed by farmers than wildlife, for example. Furthermore, many of them appear to be under threat from pressures such as felling for timber and conversion of forests to other land uses. They are therefore prime candidates for CTU. However, many of the concepts discussed are applicable to other forms of flora and fauna, and to other forest types or regions where conservation priorities and local people's development goals need to be reconciled.

Socioeconomic, cultural and biophysical conditions vary widely throughout the MTDF region

In extrapolating the results presented here beyond the two areas on which this study focuses (described in Chapter 2), the reader should take into account the specific socioeconomic, cultural and biophysical characteristics of these study areas, and the fact that these conditions vary widely across other parts of the MTDF zone and across other ecosystems and regions.

2. The Mesoamerican tropical dry forest in context

The Mesoamerican tropical dry forest (MTDF) has been subjected to alteration, fragmentation and deforestation as a result of human activity. Many of the people living in the MTDF zone suffer severely from poverty, which is exacerbated by the erosion of the natural resource base on which they depend. Traditional approaches to conservation, based on state regulation and the establishment of protected areas, have had limited success because of pressures from the local population to use land and tree resources to support their livelihoods, and poorly developed conditions of governance. There is also a risk that conservation initiatives based on exclusion will impose significant social and economic costs on local people. Alternative conservation strategies are therefore called for in the MTDF.

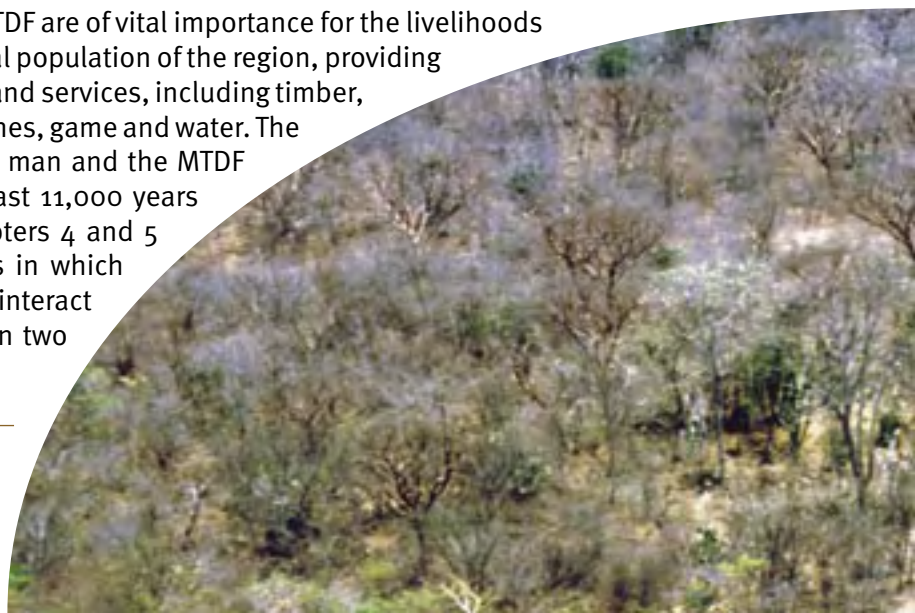
Where and what is Mesoamerican tropical dry forest?

Dry forest once stretched from the Azuero peninsula in Panama to Baja California Sur in northern Mexico. Between these two extremes, the natural range of Mesoamerican tropical dry forest (MTDF) covers most of the Pacific coast of Mexico and Central America, many interior valleys and also parts of the Yucatán peninsula in Mexico (Fig. 2.1). It is usually found below 1,000 metres above sea level, on coastal plains and foothills, although in interior valleys it may reach higher altitudes. Virtually all of the forests described here are found within the (sub)tropical dry forest (*bosque seco (sub)tropical*) life zone (Holdridge et al., 1971).

Specific characteristics of MTDF are that it has a closed canopy in its undisturbed state and is deciduous (away from permanent watercourses) with at least 50% of canopy species losing their leaves for at least 3 months of the year because of seasonal drought. However, rainfall is typically highly variable between years, with ecological consequences that are not yet fully understood. Included in this definition are both low deciduous forest (*selva baja caducifolia*) and medium semideciduous forest (*selva mediana subcaducifolia*).

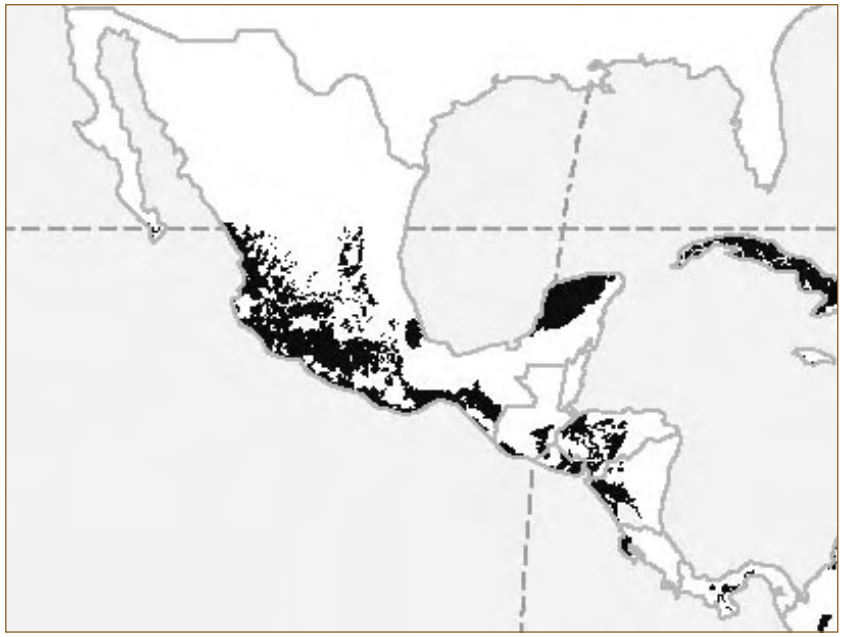
Why is Mesoamerican tropical dry forest (MTDF) important?

The trees and forests of the MTDF are of vital importance for the livelihoods of the predominantly poor rural population of the region, providing them with essential products and services, including timber, firewood, fodder, fruit, medicines, game and water. The intimate association between man and the MTDF is thought to date back at least 11,000 years (Bullock et al., 1995). In chapters 4 and 5 we look in detail at the ways in which local people depend on and interact with MTDF trees and forests in two case study areas.



Dry forest, here in southern Honduras, is characterised by seasonal loss of leaves

Figure 2.1 The distribution of Mesoamerican tropical dry forest in the year 2000



Source: Miles et al., 2006

The MTDF is also of great global importance. From a biological viewpoint, it is of interest because of its unique fauna and flora that includes elements from both South and North America. It also contains a large number of endemic species: for example both the North Central American Pacific Slope and the South Central American Pacific Slope are classified by BirdLife International (2003) as Endemic Bird Areas, of 'high' and 'urgent' conservation priority respectively. WWF classifies Mexican dry forest as one of the Global 200 most biologically outstanding habitats in the world and considers it to be "the richest tropical dry forest in the world with high levels of regional and local endemism" (WWF, 2004). In Costa Rica, an 11,000 ha area of dry forest in Santa Rosa National Park was estimated to contain 13,000 species of insects, 175 breeding species of birds, 115 species of non-marine mammals and 75 species of reptiles and amphibians (Janzen, 1988).

Many important crops such as maize, beans and squashes were domesticated from the MTDF (Toledo et al., 1989; Maass, 1995). It is also home to a large number of globally useful and versatile tree and shrub species, with characteristics such as durable timber, rapid growth, palatable fruits and the ability to coppice, fix nitrogen and withstand prolonged drought. These characteristics have led to many of them being planted elsewhere in the tropics, where a number (e.g. *Leucaena leucocephala* and *Gliricidia sepium*: Hughes, 1998; Stewart et al., 1996) now form the basis of smallholder livelihoods and commercial forestry enterprises. In

MTDF at the turn of the Millennium

Throughout most of its range, MTDF has been severely altered by centuries of human activity, dating from pre-conquest times and increasing in intensity to the present day. In 1986, it was estimated that less than 2% of the 550,000 km^2 of dry forest that existed on the Pacific coast of Mesoamerica when the Spanish arrived, was by then "sufficiently intact to attract the attention of the traditional conservationist" (Janzen, 1986). When intact dry forest is replaced by fencerows, ditches, pastures and woodlots, the species richness of the breeding fauna and flora is reduced by 90 to 95% (Janzen, 1988). In Mexico, only 27% of the original cover of seasonally dry tropical forest remains (Trejo and Dirzo, 2000). The gloomy picture is supported by Miles et al. (2006), who rank MTDF as among the most threatened dry forest regions on earth.

A number of different landscapes can be distinguished today in the area over which MTDF once occurred naturally:

Cyclical steep land agroecosystem

Deforestation has been particularly severe on the Pacific-facing slopes of El Salvador, Honduras and Nicaragua. Here, MTDF has been largely reduced to an agroecosystem consisting of a shifting mosaic of fields, fallows, pastures and small secondary woodlands. Aerial photographs of the agroecosystem of southern Honduras show that the area of fallow in the landscape is progressively reducing. These shrinking fallow areas are secondary in nature and different in structure to mature dry forest. However, in the Central American agroecosystem they may include the only remaining areas of closed canopy vegetation left in the landscape, and are therefore important as habitat for fauna and as a source of the 'seed rain' on which the regeneration of dry forest trees depends. As will be seen in Chapter 4, this landscape contains large amounts of tree material, in fallows and woodlands, and also as scattered trees, live stumps and seedlings in fields.

Extensive, apparently intact forests

In the western and southern Mexican states of Jalisco, Michoacan, Guerrero and Oaxaca, large expanses of forest remain. Although apparently intact, in reality much of this area may at some time or other have been subjected to temporary clearance for the establishment of small agricultural plots, or to grazing and browsing by livestock. In a number of areas these forests currently face serious threats from agriculture, ranching, roads and tourism development. It has been estimated that half of Mexico's MTDF has been severely altered or converted to other uses (Trejo and Dirzo, 2000).

Commercial lowland agriculture

Substantial areas of the coastal plains and interior valleys of both Central America and Mexico are dominated by large land holdings on which commercial agriculture (such as melon and sugarcane production) is practised. Because of the flat topography and the value of these crops, most of the original tree cover, including stumps, has been mechanically removed. Trees are mostly confined to fence lines where opportunities for regeneration are limited and, in the case of sugarcane plantations, they are subject to damage from fire.

Ranch lands

Other parts of the coastal plains and interior valleys of Mexico and Central America are dominated by poorly managed cattle pasture. Such pastures are also present on hill lands, such as those of the dry zone of north-western Costa Rica. In some areas, large shade trees of species such as *Enterolobium cyclocarpum* and *Albizia saman* are common, some of which may be remnants of the original forest cover, or may be natural savanna species that now benefit from forest conversion. Other lowland pastures are dominated by small, scattered *jícaro* trees (*Crescentia alata* and *C. cujete*). Where grazing is either not practised or is carried out at very low intensity, there is dense natural regrowth of shrubby species such as *Caesalpinia coriaria*.

At the species level, there is concern that many MTDF trees have suffered severe declines in their numbers and in the genetic diversity of their populations. In some cases mature MTDF trees scattered through the agricultural landscape have been described as 'the living dead' (Janzen, 1986), as the conditions in the degraded landscape around them appear to make it virtually impossible for them to regenerate.

Current threats to MTDF trees and forests

There is no precise information about which MTDF species have already been lost as there are no old botanical checklists to compare against. There are a number of processes, however, that are having a far-reaching impact on the current range and composition of the MTDF.

Smallholder agriculture

The initial clearance of much of the original hillside forest in the MTDF zone was carried out by small farmers, marginalised from the fertile lowlands by ranching and commercial agriculture. Over much of dry zone Central America, clearance of original forest is now largely a thing of the past as almost all of the landscape has already been converted to a cyclical agroecosystem. However, there is a progressive reduction in the fallow area in the landscape of southern Honduras, due to growing population pressure that is yet to be fully compensated by emigration trends (see Fig. 2.2).

Cattle

Cattle ranching has led to the elimination of large areas of forest and fallow, in both Mexico and Central America. Once pastures are established, tree regeneration tends to be hampered both by grazing and by the practice of burning pasture to encourage new growth and eliminate ticks. The scale of ranching in Central America has been largely tied to US demand for cheap beef (De Walt, 1983). This reached its peak in the mid–late 20th century but subsequently became less viable because of a slump in US demand, leading to a reduction in the cattle herd and the abandonment of many ranches, for example in the Guanacaste area of Costa Rica. However, ranching continues to be an attractive option for many farmers, especially under conditions of labour shortage resulting from the progressive emigration of the economically more active sectors of the population. It requires limited investment of labour and other resources and permits the assertion of property rights over large areas of land. Capital held in

the form of cattle is easily converted into cash and, despite declines in export markets, prices for beef tend to be subject to less annual variation than most other crops.

Fire

Fire is commonly used as a tool for resource management. In staple grain production systems, it is often used as a site preparation method, especially in areas with thorny vegetation and where labour is scarce. As described above, in ranching areas fire is used to regenerate pasture and eliminate ticks. The balance of opinion amongst ecologists is that fire is not a natural part of MTDF ecology. It is now common for protected area managers to treat all fires as unnatural and eradicate them (Janzen, 1986). Support for this comes from Puerto Rico where Murphy and Lugo (1986) report no natural fires in tropical dry forest during 50 years of protection. However, not all authors are convinced that natural fires never occur in MTDF (Middleton et al., 1997; Otterstrom and Schwartz, 2006). What is certain is that human induced fires, occurring at frequencies far greater than anyone would suggest for wildfires, have had a drastic and, at least from the point of biodiversity, detrimental effect on MTDF biota. Frequent burning affects the natural species composition by eliminating some species and favouring others (Otterstrom and Schwartz, 2006) and alters the course of ecological succession.

Timber extraction

The high quality and value of the timber of many MTDF tree species (such as *Bombacopsis quinata, Cedrela odorata, Cordia alliodora* and *Swietenia humilis*) means that they are commonly felled, for use in construction and furniture manufacture. Past over-exploitation of some species for industrial purposes has reduced the standing value of this resource (Gordon et al., 2005). As will be seen in Chapter 4, the demand for timber can in some cases motivate farmers to nurture trees as a source of income. However much of the felling that takes place is in the form of poaching, especially in areas where individual access rights are not well defined, and this can lead to the progressive degradation of tree populations. The value of other forms of tree product can at times also contribute to the degradation of tree populations. In some areas of coastal Oaxaca, for example, populations of *Amphyteringium adstringens* are apparently being over-exploited by local people because of the demand for its bark, which is sold for medicinal use. This case is examined in more detail in Chapter 5.

Commercial agriculture

The expansion of commercial crops, such as cotton, sugar cane and melons, has played a significant role in the elimination of large areas of dry forest in southern Honduras, as is evident from historical records and aerial photographs of the coastal plains. Similarly, local people report that forests on the coastal plains at the western extremity of coastal Oaxaca were cleared with Government assistance in the middle of the 20th century. Today, much of this area is used for the production of citrus fruits. In both countries, the threat of the expansion of commercial agriculture is now largely in the past, as virtually all of the forest on flat land suitable for mechanised cultivation has already been cleared.

Tourism development

The development of tourist resorts has contributed to deforestation in Mexico (Ceballos and

García, 1995), particularly along the coast. Some parts of the MTDF region have high potential for ecotourism, which can – if managed appropriately – serve to motivate conservation, to generate income for local communities and thereby to counterbalance some of the negative impacts of resort-based tourism. Despite the existence of some promising examples, however, the full potential of ecotourism in the region is far from being realised.

The people of the dry forest

Historically, the natural conditions of dry forest areas made them more attractive for settlement than the disease-ridden, difficult to clear forests of the humid tropics. Significant numbers of people lived throughout the Mesoamerican dry forest zone in pre-Columbian times (Newson, 1992) and Berrío et al. (2006) trace human impact on western Mexican dry forest back 2,700 years.

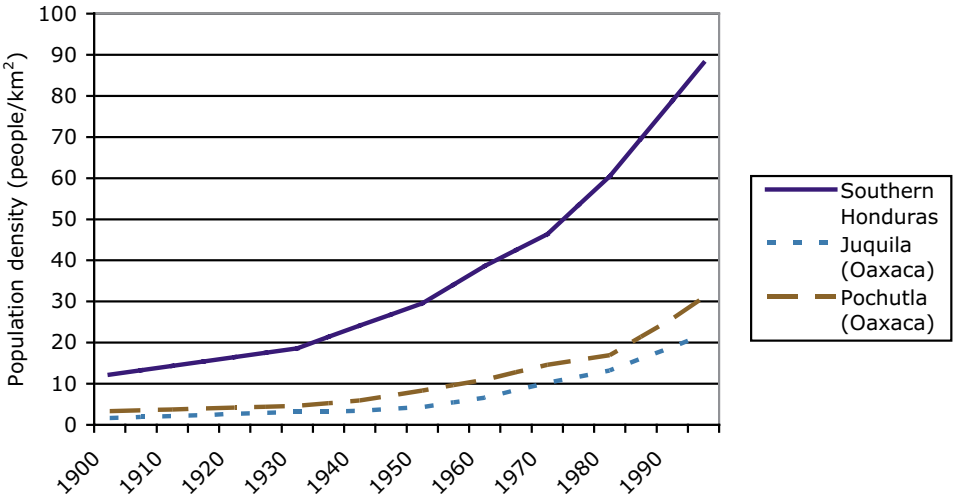
The Spanish conquest led to a population collapse of staggering proportions among the area's indigenous people, especially on the coastal and inland lowlands of Central America, because of a combination of diseases, slavery and excessive demands for tributes (Newson, 1992). This phenomenon was rather less severe in southern Mexico, due partly to a recognition by the colonial authorities of the need to ensure the survival of a labour force.

Most of the indigenous population of the Central American dry forest zone, who managed to survive the conquest, were obliged to leave the lowlands to make way for the cattle and cash crops introduced by the Spanish settlers. These patterns of economic activity persist to the present day. As a result, land tenure in southern Honduras and neighbouring parts of Central America remains highly polarised between large landholdings on the fertile plains and small farms on the surrounding less fertile, dissected slopes. Land reform initiatives in the 1960s and 1970s in Honduras were largely ineffective because of inadequate provision of support to the beneficiary groups. In neighbouring Nicaragua much of the reform undertaken by the Sandinistas during the 1980s has since been reversed.

In southern Mexico, by contrast, very extensive areas of land are held under communal tenure arrangements. This is due to the less complete eradication of indigenous culture by the Spanish conquerors, and the much more effective and universal land reform process of the 1930s, following the Mexican revolution. As will be shown in later chapters, this communal tenure is linked to communal decision-making structures, even though some communal land is, in reality, under *de facto* private tenure.

Population growth in Central America has been exponential, particularly during the 20th century. Southern Mexico has lower population densities but similarly high growth rates. Figure 2.2 shows trends in population densities in southern Honduras and in the two Districts of Juquila and Pochutla, which are at the heart of the dry forest zone of the Oaxacan coastal region in Mexico. These growth rates occur despite high levels of out-migration to the lowlands, the cities and – especially in southern Mexico – to the better off states of northern Mexico and to the United States.

Figure 2.2 Trends in population densities in southern Honduras and the Oaxacan coast of Mexico



Sources: DGECH 1993, Rodrígez Canto 1995, Stonich 1993.

Poverty in the Mesoamerican dry zone

Rural areas in both of the countries included in this study, Honduras and Mexico, are characterised by high levels of poverty, food insecurity, low levels of income and substandard living conditions (see Box 2.1). There are strong links between the level of poverty and the condition and management of natural resources. This is particularly true in the dry zone. On the hills, land tenure inequities and population growth mean that productive land is in short supply. At the same time, the ways in which many farmers manage their land and vegetation,

Box 2.1. Some indicators of poverty in the Mesoamerican dry forest zone

- In 1999, 75% of rural households in Honduras were below the poverty line and 61% were in conditions of extreme poverty.
- The average Human Development Index of Honduras stood at 0.664 in 2004. The figures for the departments of Choluteca and Valle, included in this study, were 0.627 and 0.649 respectively.
- The average Human Development Index in Mexico was 0.803 in 2004, compared to 0.734 in Oaxaca.
- In 14 dry forest municipalities of southern Honduras, more than 40% of households were found in 1988 to have more than 3 basic needs unsatisfied.

Sources: Republic of Honduras (2001), UNDP (2006a, 2006b)

such as burning fields prior to sowing, lead to problems including soil fertility loss, surface crusting, reduced rainfall infiltration and increased evaporation of soil moisture. This exacerbates pressures on the available land and increases the vulnerability of agricultural production, and therefore livelihoods, to variations in rainfall cycles. In addition, limited advantage is taken of the potential of the products and services provided by trees and forests to contribute to broadening the narrow income base which characterises much of the rural population (Barrance, 2000; Benítez et al., 2005; MacQueen et al., 2001).

These problems are made worse in many areas by poor physical access to markets, as a result of broken topography and limited infrastructural development. Farm families' ability to participate in markets and to take advantage of technological developments is further constrained by their typically low levels of education and, particularly in Central America, their low levels of organisation.

Steep hillsides in southern Honduras make both agriculture and access to markets difficult

Existing conservation approaches in the MTDF

Conservation initiatives to date have been limited in their extent and effectiveness. A major challenge is to reconcile conservation with the development needs of the population of the MTDF zone. The different approaches that have been applied to the conservation of the MTDF are reviewed below.

In situ conservation

In situ conservation involves the conservation of flora or fauna in the location *and the ecosystem* (in as natural a state as possible) in which they naturally occur. This normally requires the declaration of reserves or protected areas, where human activities are restricted to a greater or lesser extent. The World Conservation Monitoring Centre estimates that only 4.3% of the remaining deciduous and semi-deciduous broadleaved forest in Central America is currently conserved *in situ* in protected areas (WCMC, 2004). In Box 2.2 we describe some of the most significant dry forest protected areas established to date. In general, the establishment of protected areas has been hampered by the high levels of pressure from farming activities, which have made it impractical to take significant areas of land out of production.

Constraints to *in situ* conservation have been least significant in the dry north-west of Costa Rica. Here, the abandonment of large cattle ranches due to falling beef prices in the 1980s freed large areas of land for forest regeneration and restoration. However, even here, some of the land affected did not become available for conservation activities until the 1990s or faced competition from alternative land uses, such as rice production. In certain areas, conflicts arose with local people who were to be affected by protected area establishment.

Box 2.2 Some important dry forest protected areas in Mesoamerica

The **Chamela-Cuixmala Biosphere Reserve** in the western state of Jalisco in Mexico is one of the best preserved areas of dry forest in the region. Threatened by a tourism development scheme, the area was effectively protected by a legal and public campaign highlighting its biological value and uniqueness (Ceballos and García, 1995). It covers 13,142 ha and includes low deciduous forest and medium semi-deciduous forest, on land acquired from a few large landholders. The strictly preserved core zone, to which access is highly controlled, makes up 70% of its area. In the remaining buffer zone, various activities compatible with the maintenance of forest cover are permitted, subject to a high level of control.

The terrestrial part of the 6,000 ha **Huatulco National Park** in Oaxaca, Mexico, (Gordon et al., 2006) protects dry forest adjacent to the recently developed Bahías de Huatulco tourist resort. The forest is largely secondary and had previously been used by local communities. When the land was expropriated by the federal government for the establishment of the tourist resort, the communities were compensated with land elsewhere in the municipality, but at significant financial and social cost to them. One community which refused to be relocated remains within the park boundary.

The **Chacocente Reserve** on the southern Pacific coast of Nicaragua (Gordon et al., 2006) comprises 14,800 ha of tropical dry forest, zoned into core and buffer areas, as well as important turtle nesting beaches. In what is one of the poorest areas of the region, the park management has been faced with various conflicting claims on forest products from local landowners and farmers, which are incompatible with conservation to varying degrees. Considerable investment is planned, both in and around the park, to establish effective management that respects private property and the need of local people to utilise resources in support of their livelihoods.

One of the longest established and most important protected areas in the region is the 88,000 ha **Guanacaste Conservation Area** (GCA) in the north-west of Costa Rica, which brings together a number of smaller protected areas within a matrix of connecting agricultural landscape. Central to the management approach here is the restoration of dry forest in former pasture areas, through the establishment of 'nuclear' seed trees and the suppression of fire (Janzen, 1986). The **Tempisque Conservation Area,** in the same region of Costa Rica, also contains large areas of intact dry forest in a number of protected areas such as the Lomas Barbudal Biological Reserve and the Palo Verde National Park.

Experiences in some of the dry forest areas of Mexico have been different. Here, relatively low population densities and the existence of communal tenure and community-based structures for natural resource management have allowed large areas of forest to survive (see Chapter 5). Initiatives on the part of federal authorities to establish protected areas have tended to be treated with mistrust or as impositions (Castillo et al., 2005), but there have been important advances in the establishment and management of community-based protected areas, as in the case of the communal lands of Santa María Huatulco in southern Oaxaca, Mexico (Box 5.2).

Integrated Conservation and Development Projects (ICDPs)

The concept of ICDPs evolved as a result of the limited success of conventional approaches to protected areas, based on exclusion and regulation, in conserving biodiversity in developing countries (Wolbers, 1998). ICDPs aim to protect biodiversity by providing local

communities, especially those living in or around protected areas, with tangible incentives for conservation management (Sekhran, 1996). Examples of ICDPs in Central America include the Community Sustainable Self-Development Project in the Buffer Zone of Piedras Blancas National Park and Golfito Wildlife Refuge, Costa Rica, and the Mayan Forestry Action Plan in Guatemala. This strategy has had varying degrees of success (van Schaik and Rijksen, 2002). In the Maya Biosphere Reserve in Guatemala, for example, where sustainable development activities are intended to provide an economic alternative to deforestation, the approach has encountered a number of problems. Implementation has been hampered by complexity, poor understanding of biophysical considerations, limited empowerment of local people to resist external threats and possible unintended exacerbation of threats to biodiversity (Brown, 2002). Such difficulties have led to criticism of the ICDP concept and a restating by some of the need for strictly protected areas (Terborgh et al., 2002).

Ex situ conservation

Ex situ conservation involves the removal of flora or fauna from the location where they naturally occur, and their conservation either in a dormant state (e.g. as tissue or seed) or in breeding populations (e.g. in zoos or seed orchards). During the 1980s and 90s, much work was carried out in Central America in exploring and collecting the genetic resources of dry forest tree species, such as *Bombacopsis quinata* (CONSEFORH, 1998a), *Cordia alliodora* (Boshier and Lamb, 1997), *Gliricidia sepium* (Stewart *et al.*, 1996) and *Leucaena* spp. (Hughes, 1998). Breeding seed orchards were established, with the double objective of conserving the species' genes in isolation from the threats that they face in the wild, and of producing high performance seed to be used in forestry and agroforestry projects both within and outside the region. In practice, these two objectives have proved difficult to reconcile, as conservation goals would normally require the maintenance of patterns of genetic diversity in as near a natural state as possible, whereas on-station tree improvement involves their modification, through processes of artificial selection (Barrance, 1997). Such orchards are also expensive to establish and maintain, leading to significant doubts about their sustainability, given the resource limitations typically faced by the national forestry institutions which manage them.

Circa situm conservation

There is growing evidence that the continued conservation status of many globally important Mesoamerican tree species is largely due to the protection, planting and management of trees by local farmers in the heavily altered agroecosystem which is all that remains of the original MTDF throughout much of Central America. For example, large proportions of the populations of many of the 22 known species of *Leucaena* in Mesoamerica are found in disturbed agroecosystems rather than in intact forest (Hughes, 1998). Although there is increasing recognition of the potential of MTDF tree species to contribute to farmers' livelihoods through inclusion in forestry and agroforestry programmes, little attention has as yet been paid to promoting the *circa situm* protection of trees in agroecosystems specifically as a strategy for biodiversity conservation (CONSEFORH, 1998a and 1998b).

Ecological restoration

The *in situ* conservation carried out in the Guanacaste Conservation Area in Costa Rica has been complemented by the restoration of elements of tropical dry forest on former pasture

land, through a combination of practices including the planting of nuclear seed trees to promote seed dispersal, and the suppression of fire (Janzen, 1986) (see Box 2.2). In Costa Rica this was made possible by the abandonment by ranchers of large areas of pasture. In the smallholder landscape of the southern Honduran hills, however, this practice is less applicable because of the limited availability of land that can be taken permanently out of production.

Biological corridors

The ability of fauna and flora to move and breed between areas of habitat is important in increasing the effective size of their habitats and promoting the diversity of populations. Recognising the importance of regional action on conservation in Central America, a relatively small physiographic unit with many common elements (Campos Arce et al., 2005), the Mesoamerican Biological Corridor (MBC) was established in 1997. The MBC promotes the concept of 'connectivity' at a regional level, and emphasises the compatibility between conservation and sustainable development in the landscape that separates protected areas (Miller et al., 2001). The MBC aims to establish a number of parallel regional corridors, one of which follows the dry zone of the Pacific coast of Central America. A major challenge facing this initiative is how to ensure that the protected areas identified for inclusion in the MBC actively contribute to connectivity, and that they enjoy sufficient resources to avoid becoming 'paper parks' (Utting, 1993).

Conservation through use

Conservation through use (CTU), the theme of this book, is by no means a new phenomenon in Mesoamerica, and in fact underlies many of the above approaches. The human populations of the region have for generations depended for their livelihoods on a range of products and services obtained from trees and forests. Local communities also commonly protect trees around water sources and nurture or plant certain species that yield valued products. As noted above, the *circa situm* conservation by farmers of many species of *Leucaena* is largely motivated by their perceived use value, for example, in the case of *L. esculenta*, as a source of edible pods (Hughes, 1998). However, some initiatives in the region to promote NTFPs as a means of motivating local producers to conserve their forests, have raised concerns over the long-term impacts on the resources in question. For example, the extraction of dyes from the Maya Biosphere Reserve in Guatemala (a humid area of Mesoamerica) is predicted to lead to eventual over-exploitation of some species (Goulda et al., 1998). To date little attention has been paid to determining, or actively promoting realisation of, the potential contribution of CTU to the conservation status of trees and forests in the MTDF, or its implications for farmers' livelihoods.

Rural development initiatives related to MTDF trees and forests

There have been a large number of initiatives in the region that have sought to promote the livelihoods of local people through the incorporation of MTDF trees into farming systems and plantations, or through the sustainable management of natural forests. The results have been mixed. Table 2.1 summarises the results of a selection of early reforestation projects.

Table 2.1 Results from a selection of tree-based projects

Case study	Main components	Key results
Reforestation using incentives in the Hojancha region of Costa Rica	• Establishment of plantations to generate income and take advantage of Government incentive scheme	• Large numbers of trees were established • Some producers managed to sell trees and seed, but few managed to sell the products of thinnings • Internal rates of return varied between 16.4 and 27.1% • The nurseries were an important source of employment and income • The system was robust to price variations • Doubts remain about how benefits were distributed • Participation and decision-making were dominated by men
Agroforestry support to resource poor rural communities in El Salvador	• Establishment of pure plantations and association of trees with soil conservation • Fallows enriched with *Gliricidia sepium* • Alley cropping, live fences and contour planting	• Levels of adoption of technologies ranged between 4 and 17% • The profitability of the tree/crop combination systems was low • Taungya and improved fallow systems were highly profitable and robust to variations in price, costs and yields
COHASA I in Honduras	• Establishment of communal nurseries • Establishment of forestry plantations	• Nurseries producing timber and fruit trees were managed as businesses by local people on a long-term basis • 1,400 ha of trees were established • Many producers lost interest in establishing plantations once incentives were suspended

Source: Current et al., 1995

A number of factors have been identified as affecting the success of tree management projects in the region, including the following (Barrance and Hellin, 2003):

- **Use rights:** to be interested in planting trees, farmers must be sure of their rights eventually to obtain benefits from them. This does not necessarily mean that farmers need to possess formal title to the land. In some cases, over-restrictive laws may reduce farmers' confidence in their rights to use and manage trees.
- **Multiplier effect:** many projects focus their extension efforts on particularly active 'model farmers', in the hope that these will communicate technologies to others, leading to a progressive multiplication of the numbers of farmers applying the technologies. In practice, this effect has often been limited, either because of a lack of commitment

and/or capacity on the part of the leader farmers, or because the technology itself is not appropriate to the conditions and needs of other farmers.

- **Technologies:** many technologies, which have appeared promising in other regions or experimental stations, have failed on farm. Successful technologies must be appropriate in productive, social and biological terms, and must complement farmers' other activities and components of their farms. In addition they must not require small farmers to assume risks that may affect their livelihoods.
- **Incentives:** the provision of economic, fiscal and/or material incentives has in some cases led to high levels of reforestation activity. However, the effects of this strategy have often been short-lived, as farmers may be motivated more by the incentives than by a genuine belief in the technologies, and may abandon them once the incentives are withdrawn.

Many projects have underestimated the potential of native tree species and naturally regenerated tree material. High performing exotic species such as eucalypts, neem (*Azadirachta indica*), teak (*Tectona grandis*) and *Gmelina arborea*, have often been emphasised at the expense of native species, many of which yield high quality, locally familiar products and can be cheaply established through natural regeneration.

In general, uptake by farmers of tree-based rural development activities has been low, in spite of the large amounts of resources invested, for example, in incentives and tree nurseries. At the same time, the full value of native MTDF tree species and forests has not been appreciated (Barrance and Hellin, 2003).

There are exceptions, however. The Lempira Sur project in western Honduras, for example, has had considerable success in promoting the widespread adoption by farmers of a locally-developed management system termed *Quezungual*, which involves the protection and coppicing of naturally regenerated trees in fields and the use of the resulting mulch to conserve soil humidity for crops. This practice, variants of which exist in other parts of Central America, has proved eminently compatible with the needs of small hillside farmers. It requires minimal investment of labour and other resources, and addresses directly the scarcity and unreliability of soil moisture, one of the most crucial factors affecting staple grain production (Clercx and Deugd, 2003). The extensive plantations of *Bombacopsis quinata* in Costa Rica represent another of the few cases in the region in which a native species has been subject to widespread planting by farmers.

There have been only a few attempts to promote rural development through sustainable forest use in the MTDF and even fewer successful experiences. Two cases in Oaxaca are discussed in more detail in Chapter 5. In Costa Rica, meanwhile, there have been successful experiences of raising iguanas for sale in small woodland areas. The conservation benefits of this practice, however, tend to be limited because of the restricted scale and biological importance of the woodlands involved.

3. Case study areas and research methods

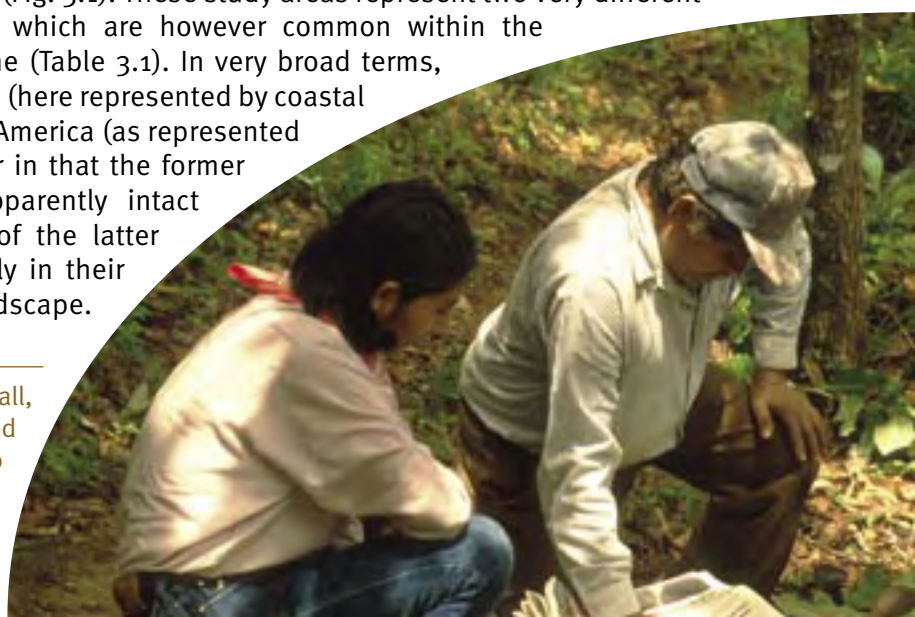
This chapter describes the case study communities and outlines the methods used to investigate the potential of conservation through use in two areas within the Mesoamerican tropical dry forest Zone. Socio-economic research methods were used to understand how local people use and manage their tree resources, while policy studies in both countries provided an overview of the policy context. A rapid botanical survey helped to define which species and sites in the case study areas are of highest priority for conservation.

An integrated research approach

Questions relating to the complex interaction of people and natural resources can best be answered by drawing on some combination of quantitative and qualitative information (Schreckenberg et al., 2005). This research therefore included a number of different components ranging from more qualitative farmer interviews to highly quantitative botanical inventories, and economic studies lying somewhere in between. The key to the effective combination of methods and data lies in the iterative relationship between descriptive (usually more quantitative) and explanatory (more qualitative) approaches (Holland and Campbell, 2005). In practice this meant that the components were carefully phased, so that the results of one strand could feed into another. There was a continuous flow of information between team members involved in the different research components throughout the fieldwork period. Following completion of the fieldwork, the resulting biological, social and economic information was brought together to analyse the conservation significance and potential of the tree and land use management practices identified. As a development research project, there was a strong emphasis on achieving buy-in by the eventual users of the research results and on capacity-building of partners throughout.

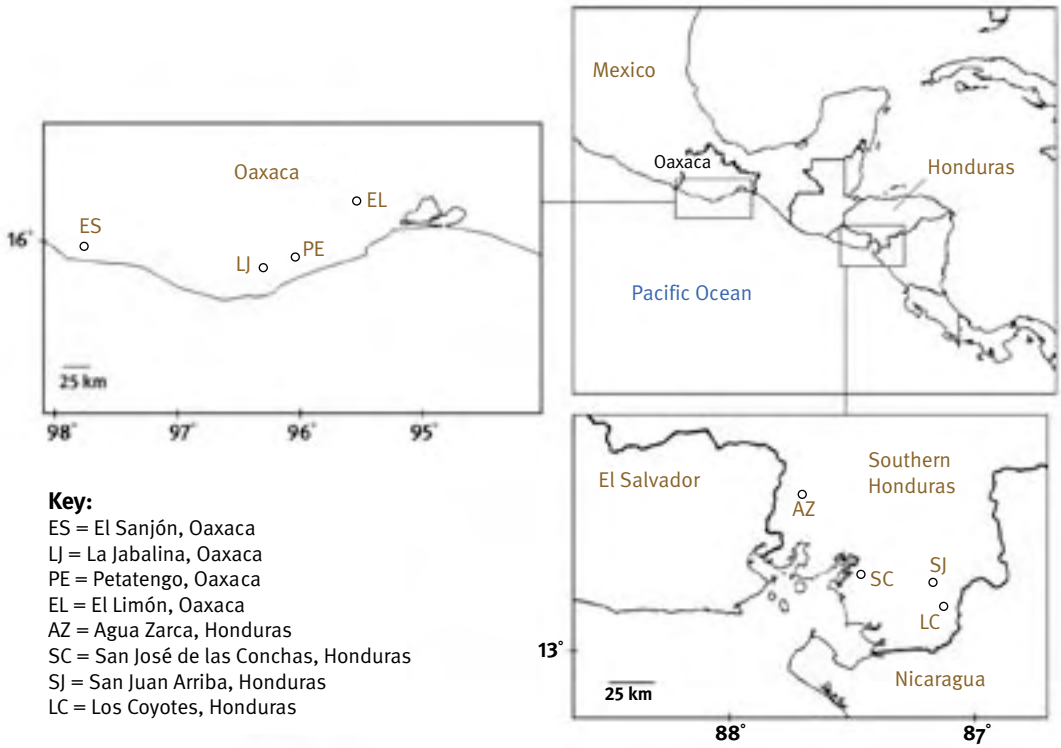
Study areas

The research focused on the two case study areas of southern Honduras and the coastal zone of Oaxaca state, Mexico (Fig. 3.1). These study areas represent two very different sets of conditions, both of which are however common within the Mesoamerican dry forest zone (Table 3.1). In very broad terms, the dry forest zones of Mexico (here represented by coastal Oaxaca) and most of Central America (as represented by southern Honduras) differ in that the former contains large areas of apparently intact forest whereas the forests of the latter have been converted virtually in their entirety to an agricultural landscape.



The botanical team at work – in all, some 260 land units were sampled for tree diversity and over 9,000 records (observations of trees) were taken

Figure 3.1 Location of case study areas in southern Honduras and the coastal zone of Oaxaca state, Mexico



Key:
ES = El Sanjón, Oaxaca
LJ = La Jabalina, Oaxaca
PE = Petatengo, Oaxaca
EL = El Limón, Oaxaca
AZ = Agua Zarca, Honduras
SC = San José de las Conchas, Honduras
SJ = San Juan Arriba, Honduras
LC = Los Coyotes, Honduras

Another significant difference, of potential relevance to whether and how CTU functions, is that large areas of land in the Mexican dry forest area are held communally, whereas tenure in most of Central America is individual in nature. What the two study areas have in common is that they both contain institutions and organisations interested in participating in, and learning from, research on CTU.

Study communities

Four study communities were selected in each of the two case study areas (see Box 3.1). Between them, these represent a cross-section of the diverse physical and social conditions found in each study area. Among the factors taken into account in selecting the communities were the following:

- Altitude, ranging from sea level to about 500 metres above sea level;
- Rainfall, with less than 10% falling in the dry season months of November to May;
- Vegetation cover, ranging from lowland pastures and fruit plantations, through mosaics of maize fields and fallows, to extensive areas of largely intact forest;
- Production systems, including the subsistence production of maize, low intensity coffee production, cattle ranching at different scales, and fruit production in both homegardens and plantations;

Table 3.1 General characteristics of the study areas

	Southern Honduras Specifically, the coastal plains and foothills of the Departments of Choluteca and Valle, around the Gulf of Fonseca. These are typical of the Pacific drainage of much of Central America.	**Coastal Oaxaca** Specifically, the coastal region of the south of Oaxaca, between the Sierra Madre del Sur and the Pacific Ocean as far East as the western limit of the Isthmus of Tehuantepec.
Forest condition	Dry forest almost completely converted to an agroecosystem dominated by cyclical basic grain cultivation, ranching and export agriculture, with scattered trees and fragmented secondary woodlands	Large areas of apparently intact dry forest, but significant areas converted to shifting and permanent agriculture
Social conditions	High levels of poverty, low levels of community organisation	High levels of poverty, well developed organisational structures
Tenure	Almost exclusively private (*de jure*/*de facto*) and individual; highly polarised between large commercial holdings on the coastal plains and smallholdings on the surrounding hills, much renting	Largely communal or *ejidal*, but with significant areas affected by enclosure and *de facto* individual usufruct
Population and culture	Almost entirely *mestizo*, and under exponential growth despite significant emigration	Largely *mestizo* (in contrast to many inland areas of Oaxaca and the Isthmus of Tehuantepec), with some indigenous cultural characteristics. Also showing high growth rates, but much lower population densities than southern Honduras

- **Social organisation**, ranging from communities where farmers operate largely as individuals, through *ejidos*, to highly organised agrarian communities;
- **Culture**, ranging from *mestizo* communities to those made up of immigrants from indigenous communities elsewhere, who still maintain indigenous cultural traits and language.

Socioeconomic survey

The aim of the socioeconomic research was to find out how local people perceive, manage and use trees and forests, and how this relates to their farming systems and livelihoods. Thus it attempted to assess the *local* importance of dry forest resources, while the botanical research focused on *global* importance. As farmers' livelihoods and decision-making processes are complex, semi-structured interviews were used to allow open-ended discussion and exploration of themes relating to tree management. These were combined with visits to farmers' fields at different moments in the agricultural calendar.

Box 3.1 The case study communities

Southern Honduras

San Juan Arriba: A steep-land community in the wetter east, with relatively good access to markets and off-farm employment. Many farmers grow coffee, but this is declining in importance. Much fruit is produced, and marketed through intermediaries. There are many interventions by external organisations.

Agua Zarca: A steep-land community, in the drier west, with poor access and almost exclusive dependence on staple grain production. Agua Zarca is largely bypassed by external organisations.

San José de las Conchas: Near the coast, its lands cover both a hill outlier and coastal plains. San José was established under the agrarian reform programmes of the 1960s and 1970s. Access to off-farm employment is good, and there is much cattle raising. There is relatively little external intervention.

Los Coyotes: In the wetter east, on largely steep land, but at relatively low altitude. There is much trade in timber and firewood to nearby towns and good opportunities for off-farm income. A food-for-work based forestry project worked with a farmers' cooperative in the community in the 1990s.

Coastal Oaxaca, Mexico

El Sanjón: On the coastal plains in the wetter west, this community has good soils and market access. The communal lands are almost entirely individually managed, and are mostly used for lemon and coconut plantations and cattle. A local NGO is promoting 'cellular reserves' in patches of secondary woodland.

La Jabalina: This includes several scattered hamlets in the communal lands of Santa María Huatulco, where a local NGO is facilitating community-based resource management planning. Many people have left to live nearer to the coast road and the Bahías de Huatulco tourism complex. Much communal forest remains.

El Limón: The only case study community which is an *ejido*, El Limón is in the drier east, near the markets of the Isthmus of Tehuantepec. It has received very little NGO or project support.

Petatengo: Part of the communal lands of Santa María Xadani, Petatengo includes both communally and individually managed land. A local NGO is promoting the sustainable harvesting and commercialisation of non-timber products and handicrafts from the community's forests.

A target sample size was set of 20 farm households per community. A total of 159 farmers were interviewed in the eight communities (Table 3.2). Selection of the interviewees began with a participatory wealth-ranking process (Pretty et al., 1995), in which key informants defined stratification criteria and categorised the members of their communities accordingly. Among the criteria most commonly chosen by the participants to describe economic status were the size of land holding and the number of cattle. Within each wealth category, a sample of farmers was randomly selected, approximately proportional in number to the relative magnitude of the category in the community as a whole. Those interviewed thus represented the whole socioeconomic spectrum, ranging from landless labourers to large landowners.

Table 3.2 Number of families sampled relative to community size

Community	Sample size (families)	Total community size (families)	Sampling intensity (%)
Southern Honduras			
San Juan Arriba	20	160	12.5
Agua Zarca	20	62	32.2
San José de las Conchas	20	150	13.3
Los Coyotes	19	57	33.3
Coastal Oaxaca, Mexico			
El Sanjón	20	30	66.7
La Jabalina	20	32	62.5
El Limón	20	43	46.5
Petatengo	20	130	15.4

A basic set of household data (land holding size, types and sizes of land unit, number of years in the community, etc.) was collected for each family in the sample. This was followed by an interview following a roughly predetermined structure. At the same time, the researchers encouraged the farmers to elaborate further on any particularly interesting themes that arose during the course of the conversation.

After the interviews, the researchers grouped the farmers' comments by theme (for example, reasons for protecting trees in fields and preference criteria for selecting species for different uses) and by the tree species that farmers had listed in different contexts (for example, species most valued for different uses, most protected in fields and most planted). This information, farmer by farmer, was entered into a database for quantitative and qualitative analysis.

In addition to individual interviews and field visits, focus group meetings (17 in total) were held with invited groups of community members. These meetings used a combination of open discussion and visual tools (such as matrices and timelines) borrowed from Participatory Rural Appraisal to shed further light on specific themes that had emerged in the course of the individual interviews, such as particular production systems, organisational structures and aspects of tenure.

Two more detailed economic studies were carried out to understand how existing economic motivations to manage or maintain trees are likely to impact on on-farm tree biodiversity, and how the latter is likely to change in response to economic pressures in the future. In Agua Zarca and Los Coyotes, Honduras, a comparison was made between larger less-intensive (longer fallow period) and smaller more-intensive (shorter fallow) farms (Richards, 2000). In El Limón and Petatengo, Mexico, the focus was on understanding the impact on tree biodiversity of agricultural intensification and the trend away from communal crop management (Davies

et al., 2000). In both cases, household surveys were complemented by discussions with individual key informants, focus groups and secondary data.

Policy context

The implications of existing laws, policies and institutional structures for the conservation status of the dry forest were analysed in each country by means of a literature review of present and past laws (and the institutional arrangements which they specify) and policy trends (Díaz Arrivillaga, 2000; González and Beltrán, 2000). Interviews were conducted with key informants at a number of levels, from central government through to community representatives. The methodology, together with an initial list of laws and policies to be analysed and actors to be interviewed, was discussed and refined through initial 'scoping' meetings in each country, attended by representatives of a range of governmental and non-governmental institutions.

Botanical survey

The botanical work was carried out in collaboration with herbaria in Honduras and Mexico and local NGOs in both countries. As seen in Chapter 2, the MTDF contains large numbers of tree species. It was therefore necessary to devise a practical, cost-effective yet objective method for defining and comparing conservation priorities among such large numbers of species. The botanical methodology progressed in three stages (Gordon et al., 2004):

(i) Survey and identification of species in different sites and land uses

The botanical team began by establishing a draft checklist, based on published sources and herbarium specimens, of all tree and shrub species known to occur in the study areas. They then carried out detailed surveys ('checklisting') of the tree and shrub species in the land units managed by farmers who had been interviewed by the socio-economic team. These included fields, fallows, pastures, homegardens, coffee plantations and woodlands. They also surveyed a selection of woodlands elsewhere throughout each of the study areas. These forests were not selected at random but were biased to maximise geographical coverage and include larger forest fragments. A slightly modified version of the plotless, rapid botanical survey methodology described by Hawthorne and Abu-Juam (1995) was used because of its speed and efficiency in a structurally diverse landscape (Gordon et al., 2004). This form of sampling is relatively simple, and Gordon and Newton (2006a) provide an overview of the merits of different sampling methodologies suitable for this forest type.

Each of the trees (above 2.5 cm in stem diameter) found at each site was identified to species level, by comparing them with samples held in national herbaria. Species identification in tropical countries is time and resource consuming, and should not be underestimated when planning. Local people always accompanied the botanical team, enabling them to link vernacular names to scientific names. This in turn was of great value to the socio-economic teams in interpreting and analysing the information provided to them by farmers in different communities on the use and management of different species.

(ii) Assigning species to conservation categories based on their geographical range

A number of criteria can be used to determine conservation priorities, including geographical range, threat and trends in population numbers, as used, for example, in the International Union for Conservation of Nature (IUCN) Red Lists.[2] The simplest and most objective criterion for assigning conservation priorities at a species level, when the number of species to be assessed is large, is their geographic range. This method assumes that the narrower a species' geographic range, the more vulnerable it is to extinction as a result of local phenomena and, in this respect, is similar to the 'area of occupancy' and 'extent of occurrence' parameters used in IUCN categorisations (IUCN, 1994).[3] Other factors could be taken into account, such as population numbers and structure, economic pressures and rates of habitat loss, but these are more complicated and demand data that are available for only a few species. It is impossible to assess large numbers of species in this way. For most of the 600 or more species we dealt with, such information was simply not available, whereas information on geographic range was easily compiled from herbarium collections.

The range of each species was estimated principally on the basis of herbarium specimen data, but also through the use of monographs, reliable checklists (e.g. Reyes-García and Sousa, 1997) and on-line databases such as w3Tropicos.[4] Table 3.3 presents the key used for assigning species to one of four conservation categories, from Category A for species with the most restricted ranges, to Category D for species too widely distributed to be of conservation concern.

Unidentified specimens (less than 10% of the total encountered) were not included in the analysis, with the exception of those specimens, which it was considered were highly likely to prove to be previously undescribed species. These were included in Category A. Because of their expertise in plant identification and the information on species distributions they contain, staff of national herbaria (particularly of the Pan-American Agricultural School in Honduras EAP and the National Herbarium of Mexico MEXU) played a crucial role in this research. At least as many person-hours were assigned to identifying botanical specimens and estimating species' range sizes as were assigned to fieldwork.

(iii) Comparison of conservation priority of sites on the basis of bioquality

Conservation strategies may operate not only at the level of particular species, but also at the level of sites or land uses. It is therefore important to assess the relative conservation priorities of sites and land uses, as well as individual species, in order to identify situations where conservation issues need particularly to be taken into account. A rapid and objective way of doing this is to determine the numbers of high conservation priority species present in a given site or land use. This is a measure of 'bioquality' rather than simply the total

2. http://www.redlist.org/ (accessed 26/1/04)
3. Area of occupancy is defined as the area within its 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy. Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy
4. http://mobot.mobot.org/W3T/Search/vast.html

Table 3.3 Key for assigning species to conservation categories

Criteria	Category
Endemic to the Pacific dry forest zone of Honduras or Oaxaca.	A
Endemic to the Mesoamerican Pacific dry forest zone and present in two to four Central American countries/Mexican states	B
Endemic to the Mesoamerican Pacific dry forest zone and present in five to eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific dry forest zone but present in one to four Central American countries/Mexican states.	C
Endemic to the Mesoamerican pacific dry forest zone and present in more than eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific dry forest zone but present in more than four Central American countries/Mexican states.	D

numbers of species present (biodiversity). Bioquality was scored in the form of a Genetic Heat Index (Hawthorne and Abu-Juam, 1995) for each sample site. A detailed explanation of the methodology used is provided in Appendix 1.

Feedback and dissemination

Once the fieldwork and initial data analysis had been completed, feedback meetings were held in each of the study communities. These meetings allowed for presentation and discussion of key aspects of use and management of tree diversity observed in each community, comparison of findings between communities, identification of reported and observed trends, as well as findings specific to the participants' own community or of particular significance for conservation or livelihood support.

Similar information was presented in workshops for members of NGOs, academic and government institutions working in each of the study areas, providing the opportunity for feedback and validation of results and for discussion of the implications of the research for the organisations' work. Workshops focused on how to integrate rural development and biodiversity conservation, and how to collect and use relevant information as evidence for funding proposals and policy development. This included an introduction to the concept of genetic heat, how it is calculated and how such information can help to target conservation resources. It was emphasised that low genetic heat indices for a given location do not necessarily mean that no type of conservation is required, rather that the emphasis, of that conservation should be much more heavily orientated towards local resource use. Information was also disseminated to the general public through six-monthly project newsletters, newspaper articles and radio interviews, while policy-makers were targeted by specific policy briefs.

4. Southern Honduras: Trees managed by and for farmers

In common with much of the Pacific slopes of the rest of Central America, southern Honduras is dominated by a highly disturbed dry forest agroecosystem. In this chapter we show that conservation through use is a reality in this area; many farmers actively protect those trees which they most value, particularly for timber. However this practice depends upon a number of factors, namely: the level of demand for the products and services provided by the tree in question; the inability of farmers to obtain these products and services either off-farm or through purchase; the degree to which the species involved tolerates conditions in the agroecosystem, and regenerates well; the security which farmers feel over their future rights to reap the benefits from the trees; and the effectiveness and flexibility of regulation.

Trends in land use, forest cover and tree populations

The agroecosystem that today covers most of southern Honduras is the product of centuries of disturbance. Before the Spanish conquest, the coastal plains were probably home to tens of thousands of indigenous people, who practised slash-and-burn agriculture and extracted plant and animal products from the forest (Newson, 1992; Stonich, 1993).

The Spanish cleared large areas of the lowlands for ranching and indigo production, followed in subsequent centuries by a series of other export crops, including cotton, rice, melons and sugarcane. Smallholder farmers were marginalised to the surrounding foothills. Combined with exponential rates of population growth, this process has resulted in the almost complete conversion of the original dry forest cover of the foothills to a shifting mosaic of maize fields (*milpas*), fallows (*guamiles*) and pastures (*potreros*).

Farmer interviews, review of census data, field observations and the study of aerial photographs (taken in 1954 and 1983) show that, over the last 50 years, a number of processes have shaped the current landscape in southern Honduras, including:

- A gradual reduction of fallow areas and a progressive subdivision of farms, over much of the foothills. An earlier situation of scattered agricultural clearings in a matrix of fallow has changed to one dominated by fields with permanent boundaries, only a small proportion of which is in fallow at any given time. This process is strongly linked to the growth in population density shown in Figure 2.2. In other parts of the foothill zone, little change can be distinguished over the period.

The southern Honduras agroecosystem

- Organised settlement of upland farmers on large, underused lowland holdings under agrarian reform programmes of the 1960s and 1970s, resulting typically in the conversion of areas of secondary forest, formerly used for extensive grazing, to basic grain production.
- Subsequent transfer of many of the areas affected by the agrarian reform from campesino groups to agro-industrial concerns, for the production of export crops.
- Clearance of significant areas of apparently intact lowland forest, continuing the process begun in colonial times.
- Emigration to urban areas and to the agricultural frontier areas of the humid north coast, especially during the 80s and 90s, a trend which has to some extent slowed the process of farm subdivision.
- Loss of significant areas of natural semi-deciduous coffee shade in the moister areas of the uplands, because of the marginal suitability of this area for coffee production.

Historical trends in the populations of particular tree species are hard to detect with confidence using the data sources mentioned above. However, changes in local people's use of different species can be used (with caution) as a proxy indicator. In a focus group meeting held in the study community of Los Coyotes, farmers described how the levels of use of different species had changed over recent years in response to changes in their availability. They explained how they had virtually ceased to use their preferred timber species, *Bombacopsis quinata*, as its populations in their community had been almost completely depleted over the last few decades. As a result, they are obliged to use a range of other, less highly valued, species (Table 4.1). This suggests that timber resources of some species have been reduced virtually to the point of local extinction due to over-exploitation, whereas populations of other species have remained stable.

Table 4.1 Trends in species use for timber in Los Coyotes, southern Honduras

Species	Past use (%)	Present use (%)	Change in use
Bompacopsis quinata	100	2	Decrease
Cordia alliodora	0	21	Increase
Enterolobium cyclocarpum	0	17	
Albizia saman	0	13	
Swietenia humilis	0	13	
Guazuma ulmifolia	0	13	
Simarouba glauca	0	9	
Albizia adinocephala	0	9	
Cedrela odorata	0	4	

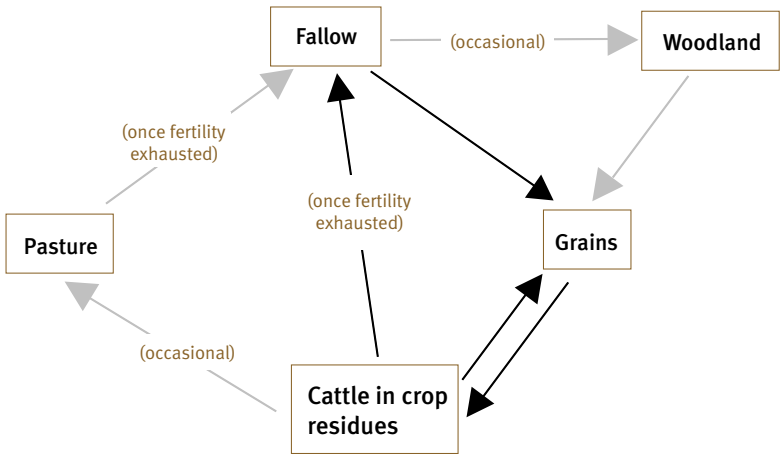
Smallholder agriculture today

The Pacific-facing slopes today are dominated by thousands of smallholders living in small villages scattered throughout the area. Average land holding size in 1993 was 5.2ha (DGECH, 1993). Given the cyclical nature of agriculture and limitations of labour and water, only a small proportion (typically less than 1ha) of this area would normally be under cultivation at any given time. Many of these farmers do not have formal title to their land. In practice, however, individual farmers' rights over particular areas of land, and the trees thereon, are normally recognised and respected by other community members. Smallholder agriculture, which is largely derived from pre-Hispanic practices, is dominated by the rain-fed cyclical production of basic grains (maize, beans and, in drier areas, the more drought resistant sorghum *maicillo*). Agricultural production at the household level is typically limited by the availability of labour.

Cropping cycles usually consist of the following phases, as illustrated in Figure 4.1:

- Manual clearance of fallow vegetation, assisted by burning when labour is scarce and/or the vegetation is thorny. The generally steep topography means that few people are able to plough.
- Sowing of basic grains using a dibble stick, with two cropping periods for maize (*primera* and *postrera*) during the six-month rainy season. Irrigation is rare, limiting factors being economic resources, steep topography and erratic river flows.
- Introduction of cattle into the fields at the end of each rainy season, to eat the crop residues (*rastrojo*).
- After repeated cropping seasons (the number of which varies according to land availability), the land is either allowed to revert to fallow, or converted to pasture by sowing grasses during the last cropping period. Small-scale farmers tend to have shorter fallows and crop their land more intensively.

Figure 4.1 Schematic representation of a typical cropping cycle in southern Honduras



- Pastures may be maintained for several years, but are usually not permanent; they tend gradually to be invaded by shrubby vegetation and converted into fallows.

Institutional environment

To be successful, conservation strategies such as CTU must take into account the roles and capacities of the institutions charged with supporting rural producers, enforcing regulation and planning and executing conservation initiatives. In Honduras, several different types of institutions and organisations are active in the field of tree use and conservation.

Government

Responsibility for the formulation of environmental policy in Honduras lies with the Natural Resources and Environment Secretariat (SERNA), which is also responsible for the definition and establishment of protected areas. Responsibilities for management and regulation, meanwhile, are split between SERNA and the Institute for Forestry Conservation and Development (ICF), a dependency of the Ministry of the Presidency.[5] SERNA is responsible for controls on the use and management of biodiversity, while the ICF manages the National System for Protected Areas (SINAPH) and enforces controls on protected areas and tree and forest use in general. To date, the ICF, like its predecessor AFE-COHDEFOR, has limited resources and capacity of its own to enforce controls and mainly relies on police checkpoints on the main roads.

Policy formulation, decision making and regulation have to date been highly centralised. Provisions in the Municipalities Law for decentralisation to municipal level have only been implemented to a limited extent, due largely to lack of confidence in the capacities and transparency of municipal governments. Few municipalities have functional Municipal Environment Units.

The interventions of the central Government in rural development and natural resource management have largely been through externally-funded development projects and programmes, under the umbrella of the National Programme for Sustainable Rural Development (PRONADERS), within the Ministry of Agriculture and Livestock. Despite the large amounts of resources that have been devoted to these, results have largely been disappointing in terms of long-term uptake of the technologies promoted and the creation of lasting local capacities (Jansen et al., 2006).

NGOs

A large number of NGOs work in the Honduran dry forest area on issues such as rural development, the provision of basic services and environmental protection. The principal motivation for promoting environmental protection is as an element of sustainable rural development. There is little NGO activity aimed at protecting biodiversity and other global

5. The ICF was provided for in the new Forestry Law, which was approved by Congress in September 2007. It replaces the State Forest Authority AFE-COHDEFOR, which was a semi-autonomous dependency of the Ministry of Agriculture and Livestock (SAG).

values for their own sake, with the exception of those organisations active in protecting the mangroves of the Gulf of Fonseca.

There has been little effective coordination of the activities of NGOs and other institutions. The efforts of different organisations often duplicate each other and may, at times, be in conflict, for example due to differing policies regarding the use of incentives to achieve results (Chenier, 1995).

Community-level organisations

Community-level organisation in southern Honduras is poorly developed. The municipal Government is represented in local communities by auxiliary mayors, who have limited roles and effectiveness. The principal formal entity at community level is the *patronato*, which is largely responsible for overseeing and promoting the community's infrastructure. There is no universal structure formally charged with protecting communities' natural resources, apart from the water committees (*juntas de agua*) where these exist, whose role is to manage communities' water supplies, including the protection of water sources and their protecting vegetation. A number of projects and NGOs have attempted to promote the establishment of community level committees to address environmental issues, but with varying degrees of success. These have in many cases tended to be perceived by community members as exclusively representing those people directly associated with the project or NGO in question. They therefore tend to lack a broad base of support and credibility. In some cases, projects and NGOs have resorted to providing material incentives to community members to encourage them to attend meetings.

Policy and legislative environment

Over the last half-century, the status of the dry forest agroecosystem has been affected directly or indirectly by a range of policies and legislative instruments related to agricultural development, land tenure, decentralisation and forestry:

- *Promotion of export agriculture*. Ever since colonial times, there has been emphasis on developing the productive potential of the lowlands. Support from initiatives such as the US-sponsored 'Alliance for Progress' in the 1960s promoted the development of 'non-traditional' export crops. These policies resulted in the clearance of extensive areas of forest in the lowlands, and marginalised the smallholder population to the foothills, exacerbating pressures on the resources there. Similarly, the expansion of export-oriented cattle ranching in the 1960s (promoted by the World Bank) had the effect of marginalising the production of basic grains by small farmers, thereby increasing the pressure on the available land and forest resources.
- *Agrarian reform*. Under the agrarian reform programmes of the 1960s and 1970s, groups of smallholder farmers from the foothills were granted underused land in the lowlands. All 'idle' land was subject to expropriation.
- *Nationalisation*. Under the 1974 'COHDEFOR Law', which formed the Honduran Corporation for Forestry Development COHDEFOR and established the Social Forestry System, ownership and management rights of trees and forests passed to the

government.[6] One of the effects of this law (intended to improve control and regulation of forest management and generate funds for the agrarian reform process) was to remove any incentive from landowners to protect trees (Suazo et al., 1997). This provision was reversed by the 1992 Law for the Modernisation and Development of the Agricultural Sector (LMDSA), which returned tree ownership rights to landowners.

- *Centralised controls*. Despite legal provisions for devolution of responsibilities to municipal authorities, the regulation of tree and forest use has remained highly centralised in AFE-COHDEFOR. In practice, enforcement by AFE-COHDEFOR has been patchy, and tree felling and sale activities are primarily controlled by police checkpoints on main roads. The new Forestry Law seeks to establish mechanisms for local decision-making and social control of forestry issues through Consultative Councils at community, municipal, departmental and national levels, however the effectiveness of these is yet to be proven in practice.

In general, forest legislation and policies have made little direct reference to the dry forest agro-ecosystem, focusing instead on the commercially important coniferous forests which dominate much of the interior of the country, and to a lesser extent the tropical broadleaf forests of the north coast. They fail to take into account the peculiarities of the dry forest typical of the study areas or the requirements of small farmers wishing to make piecemeal sales of trees arising from natural regeneration within agricultural areas. The new Forestry Law, approved in late 2007, does not significantly change this situation, although the opportunity still exists for such provisions to be made in the Regulations of the new law, which at the end of 2008 were in the process of being finalised.

How farmers use trees

The farmers interviewed in southern Honduras, in the course of this study, described a wide diversity of uses and benefits they obtain from trees, and listed the species which they most prefer for different uses. Most of the tree use described by the farm families interviewed (Box 4.1) is for subsistence purposes, principally in the form of firewood and timber for house construction. The difficulties faced by rural families in meeting their needs for tree products are often given as a justification for promoting tree-planting programmes. However, few of the farmers interviewed in this study actually reported having difficulty in obtaining sufficient tree products for subsistence.

Commerce in tree products is in most cases limited to the occasional sale of fruit, trade within the community in house posts, and the sale of occasional trees to meet cash needs.

Timber and firewood

The sale of timber and firewood is limited by problems of market access, and by the highly centralised and restrictive legal environment, which places significant time demands on farmers in obtaining permits, and does not differentiate adequately between the permit

6. COHDEFOR subsequently became AFE-COHDEFOR and, under the new Forestry Law, has been replaced by the ICF

Box 4.1 Tree uses listed by Honduran farmers, in order of importance

The following ranking is based on the number of sampled farmers who referred to the different uses.

1. Firewood
2. Timber for construction and sale
3. Fruit (for consumption)
4. Posts
5. Shade for houses and yards
6. Fruit (for sale)
7. Feed for cattle, pigs and chickens
8. Soil improvement
9. Natural medicines
10. Insecticides
11. Coffee shade
12. Shade for cattle
13. Protection of water sources
14. Environmental protection
15. Soap
16. Tools, carts
17. Animal hitching posts, chicken shelter
18. Leaves for washing dishes
19. Windbreaks
20. Setting milk for the production of curds and cheese
21. Ash for applying to banana plants

requirements for large scale commercial forest management operations and the occasional sale and transport of individual trees from agroecosystems.

In only one of the four communities studied in southern Honduras was a significant external trade in forest products found. This was the community of Los Coyotes, located close to the town of El Triunfo where there are many family-based workshops producing furniture from local timbers, especially *Cordia alliodora*. These workshops provide an important market for the trees that the farmers of Los Coyotes manage in their fields. These are typically sawn into planks at the stump and then transported manually or by mule to El Triunfo. As a result of promotion by the GTZ-funded COHAAT (later COHASA) project, farmers from Los Coyotes also sell firewood to El Triunfo and to the more important urban centre of Choluteca (Richards et al., 2000).

Table 4.2 shows the contribution that the sale of trees for timber can make to smallholder farm economies, contrasting small-scale farmers (‹3.5 ha land) with relatively low tree densities (21 trees per ha), and larger-scale farmers (›3.5 ha land) with higher densities of trees (42 trees per ha). In the best case (large-scale farmers with many trees), the net benefit from trees is at least ten times greater than that from agricultural crops, with combined tree and agricultural income about 30% higher than that obtained by small-scale farmers with fewer trees. Agricultural incomes are reduced by less than 20%, implying that tree production need not have significant impacts on food crop production. The higher per hectare net benefit from tree production achieved by larger-scale farmers

Farmer in Agua Zarca, southern Honduras, with firewood collected from a cleared fallow. More than 70% of the farmers interviewed reported being able to obtain sufficient fuelwood; 74% could get enough timber and more than 90% could get sufficient posts. These products come mostly from naturally regenerated trees in fields and fallows.

is explained by their greater capacity to access markets for tree products (Richards et al., 2000).

The situation in Los Coyotes is by no means typical of southern Honduras. In the community of Agua Zarca, the net benefit from tree production only constituted between 9 and 13% of the combined net benefit. The difference between these situations is not due to the amount of tree material present, which was approximately equal in the two communities (Box 4.2); rather, the principal factor is the availability of easily accessible markets in the case of Los Coyotes compared to Agua Zarca where road access is difficult and there are no nearby market centres for timber.

Table 4.2 Annual average economic benefits ($/ha) from trees and crops in Los Coyotes

	Small-scale farmer (‹3.5ha land and ca. 21 trees per ha) ($/ha)	**Large-scale farmer** (›3.5ha land and ca. 42 trees per ha) ($/ha)
Agricultural production		
Income	288	238
Costs (without family labour costs)	108	92
Gross agricultural return[a]/ha	180	146
Cost of family labour in agriculture	159	139
Net benefit[b]/ha	21	7
Tree production		
Income	31	177
Costs (without family labour costs)	3	49
Gross return of tree production[a]/ha	28	128
Cost of family labour in tree production	16	36
Net benefit[b]/ha	12	92

Source: Richards et al. (2000). **a.** Gross return = value of production minus costs of production, including the opportunity cost of capital, but without deducting the cost of family labour. **b.** Net benefit = value of production minus costs of production, including family labour

Non-timber forest products

A wide diversity of fruit is produced in many communities. Only communities with good access to markets (such as San Juan Arriba) commonly sell their fruit; otherwise it is mostly used for local consumption. Large quantities tend to be wasted because of pests and the lack of markets or local demand. In San Juan Arriba, market access is achieved through outside intermediaries (*coyotes*) who purchase fruit in the village and transport it to markets in nearby urban centres for resale.

Other than fruit, only two of the NTFPs found were of any economic importance to communities, and neither of these conferred widespread benefits to the local population.

- *Aceituno* (*Simarouba glauca*) soap is important in the case study community of Agua Zarca, as a substitute for purchased commercial soap. Seed is collected from female trees of this species, de-pulped and then shelled. The kernels are then boiled in water, which has previously been percolated through ash of certain preferred tree species. Soap manufacture is predominantly a women's activity; however it does little for their economic independence as it is primarily made for local consumption. Interviewees in other study communities in Honduras knew that soap could be made from *aceituno*, recognised the soap when it was shown to them, and said that older members of their communities used to make it but that the practice had now been discontinued. Extension agents report that the practice is principally concentrated in communities in the west of Valle Department, in the vicinity of Agua Zarca.
- The extraction of latex from *palo de hule* (*Castilla elastica*), a species that is confined to the wetter end of the zone and principally to riparian forest, is also geographically limited and carried out by only a few people. In the study community of San Juan Arriba, extraction is carried out by an outsider, who pays the owners of the trees a token sum for the privilege. The latex is extracted by means of incisions in the bark, which often reach high up the tree to the uppermost branches. The latex is used for the cottage-industry production of raincoats. The same latex was used by pre-Hispanic populations to make the balls used by Mayan people in the ball courts of temple sites such as Copán, in western Honduras.

Coffee farmer in San Juan Arriba, southern Honduras, wearing a coat waterproofed with the latex of *palo de hule* (*Castilla elastica*)

How farmers perceive trees

Farmers' perceptions of trees are influenced not only by the subsistence and commercial benefits they provide, but also by their impacts on crops and livestock. The farmers interviewed mentioned the negative effects of trees on annual crops much more frequently than any positive effects. The main negative effects they described were:

- Reduction of crop yields by tree shade;
- Competition for space (for example by the low-spreading *Curatella americana*);
- Damage to crops from raindrops falling from the leaves;
- Young crop plants being crushed by the leaves of large-leaved species such as *C. americana*;
- The yellowing of maize plants hit by exudate falling from *Gliricidia sepium*;

- Crop growth being affected by tree species considered to be 'hot'.[7]

The following positive effects were mentioned:

- Improvement of maize yields by falling leaves of *Albizia saman* and *A. caribaea*;
- Conservation of moisture in the *postrera* (second) sowing of maize (leading to the retention of even *Curatella americana*, otherwise considered as a harmful species);
- Provision of 'heat' by *Mimosa tenuiflora* to maize in cool periods.

Only in coffee plantations did farmers consider trees to have a net positive effect on production. In San Juan Arriba, the only one of the case-study communities in which coffee is grown in any quantity, trees are highly valued for shade as well as being a source of timber and fruit. In addition, a few producers who have received more education or training also recognise that leguminous species contribute to soil nutrient status.

With respect to livestock, the farmers interviewed made surprisingly little mention of the possible shade benefits of trees. On the contrary, it was widely noted that pasture development is adversely affected by tree shade. Tree foliage was only mentioned as being important as a source of animal fodder when cattle are introduced into fallow areas to graze or browse. Fruit were considered a more important source of fodder; cattle enjoy the fruit of *jícaro* (*Crescentia alata*), *carreto* (*Albizia saman*) and *guanacaste* (*Enterolobium cyclocarpum*).

Few farmers perceived trees in fields as having a hydrological role, although most farmers recognised the importance of protecting trees immediately around water sources. It appears that little work has been done in the region on clarifying the possible role of scattered trees and live stumps in fields in promoting rainfall infiltration and thereby buffering stream flows.

In the homegardens (*solar*) directly around the house, the principal benefit of trees was considered to be the provision of shade and coolness.

Species preferences

The farmers interviewed mentioned 67 species as being used for timber, 44 for firewood and 39 for posts (Table 4.3). However, a few species were listed much more frequently than most, including *laurel* (*Cordia alliodora*), *quebracho* (*Lysiloma* spp.) and *madreado* (*Gliricidia sepium*).

7. This 'hot' phenomenon is described for *C. alliodora*, *carbón negro* (*Mimosa tenuiflora*) and for the fallen leaves of mango (*Mangifera indica*) and *aceituno* (*Simarouba glauca*); some farmers relate it, at least in the case of *C.alliodora*, to nutrient competition and say that its severity increases with tree density.

Table 4.3 Species most reported as used for firewood, timber and fence posts in southern Honduras study communities

Species most reported as used for firewood	Species most reported as used for timber	Species most reported as used for fence posts
1. *Lysiloma* spp.	1. *Cordia alliodora*	1. *Gliricidia sepium*
2. *Cordia alliodora*	2. *Bombacopsis quinata*	2. *Cordia dentata*
3. *Albizia caribaea*	3. *Enterolobium cyclocarpum*	3. *Lysiloma* spp.
4. *Caesalpinia eriostachys*	4. *Albizia saman*	4. *Mimosa tenuiflora*
5. *Mimosa tenuiflora*	5. *Lysiloma* spp.	5. *Cordia alliodora*
6. *Gliricidia sepium*	6. *Swietenia humilis*	6. *Mimosa platycarpa*
7. *Acacia hindsii*	7. *Conocarpus/Rhizopora* spp.	7. *Bursera simaruba*
8. *Calycophyllum candidissimum*	8. *Calycophyllum candidissimum*	8. *Acosmium panamensis*
9. *Lonchocarpus* spp.	9. *Cedrela odorata*	
10. *Guazuma ulmifolia*	10. *Simarouba glauca*	

- There was a large amount of variation in species use between communities. Only nine species were reported as used in all four of the communities (*A. caribaea, A. saman, C. candidissimum, C. alliodora, C. dentata, G. sepium, Lysiloma* spp., *P. dulce and S. humilis*). These were also the species that were most frequently reported as being used in the four communities.
- Preferences are not simply a reflection of availability, however, as 16 species, although present in all of the communities, were only reported as used in one.
- Farmers are to a large extent able to satisfy their needs with their preferred species as shown by the high degree of overlap between those species reported as most used and those for which farmers express active preferences.
- Preferences tend to be very specific for different uses. *Aceituno* (*S. glauca*), for example, is preferred for making doors, *caoba* (*Swietenia humilis*) for beds, *laurel* (*C. alliodora*) for chairs, and *quebracho* (*Lysiloma* spp.) for house posts. These preferences are related to the species' characteristics; for example *C. alliodora* is valued for its strength, straightness and hardness, *madreado* (*G. sepium*) and *Lysiloma* spp. for their durability, and *S. glauca* for its resistance to splitting and to termite attack.

Access to tree products

The majority of farmers said that they did not have problems in satisfying their needs for firewood, timber and posts (see Table 4.4). Nearly a quarter of respondents did, however, report difficulty in obtaining firewood. Reasons given for limited availability of firewood included the distance between the agricultural plots (from which most firewood is obtained) and the house, limited labour availability for its collection, the conversion of agricultural plots to permanent pastures and the collection of firewood by outsiders. Shortages are to some extent seasonal, as dry firewood is difficult to obtain in the rainy season.

Table 4.4 Proportion (%) of informants in Honduras considering availability of different tree products to be sufficient (Suff.) and insufficient (Insuff.)

	Firewood		Timber		Posts	
Community	Suff.	Insuff.	Suff.	Insuff.	Suff.	Insuff.
San Juán Arriba	86	14	74	26	90	10
Agua Zarca	70	30	85	15	95	5
San José de las Conchas	87	13	90	10	90	10
Los Coyotes	71	29	95	5	100	0
Total	77	23	86	14	93	7

Farmers in lower wealth categories tended to experience greater problems of scarcity (see Table 4.5). However, the landless did not report problems obtaining posts or timber, as they have no land to fence in or build upon.

Table 4.5 Proportion (%) of informants in different wealth categories in Honduras considering availability of tree products to be sufficient (Suff.) or insufficient (Insuff.)

	Firewood		Timber		Posts	
Socioeconomic category	Suff.	Insuff.	Suff.	Insuff.	Suff.	Insuff.
A (landless)	66	33	100	0	100	0
B (with homegarden, but have to rent other land)	66	33	77	23	85	15
C (<7ha, do not rent land)	66	33	73	27	73	27
D (7-35ha)	92	8	92	8	100	0
E (>35ha)	100	0	100	0	100	0

The importance of species diversity

Rural families use a wide diversity of tree species. In the four communities studied, for example, 85 species were mentioned as used for firewood, timber and/or posts. In a focus group in the community of San Juan Arriba, participants listed 30 fruit tree species, which they actively cultivate in their homegardens.

The participants in San Juan Arriba showed, through a calendar of fruiting times, that it is beneficial to maintain a high diversity of trees in the homegarden in order to ensure that at least one species is in production in any given period of the year. In the case of trees used for firewood, timber or posts, however, species diversity is less important with most of the species reported to have more than one use. This implies that farmers do not necessarily need access to separate species for different products. The large number of species (28) reported

as being used solely for firewood is apparently due to the opportunistic nature of firewood collection: although farmers express strong preferences for certain species, in practice they tend to collect what is easily accessible. Nevertheless the 85 species reported as used for firewood, timber or posts represent only 29% of the 291 species of trees and shrubs which the botanical survey found in the study communities and surrounding landscapes.

Table 4.6 Proportions of single-use and multiple-use species in the Honduran case study communities

	Number of species	% of used species (n=85)	% of recorded species (n=291)
Species used for firewood, timber and posts	22	25.9	7.6
Species with more than one use	40	47.1	13.7
Species with only one use	45	52.9	15.5
Only firewood	28	32.9	9.6
Only timber	9	10.6	3.1
Only posts	8	9.4	2.7

How farmers protect and manage trees

Farmers protect and manage trees very differently on different parts of the farm. In this section we discuss the implications of these forms of management and protection for the status of the tree resource in the fields, homegardens and woodlots.

Fields

In spite of farmers' concerns about the negative impacts of trees on crops, 82% of those interviewed reported protecting certain species in their fields. This protection consists of taking care, when clearing fallow areas or weeding, not to cut seedlings or stump regrowth of these species. In addition, farmers protect the trees (both small and fully developed individuals) from fire, by clearing firebreaks around their bases, and by spot-burning rather than broadcast burning to clear vegetation. In some cases they avoid the use of fire completely, even though this may require increased investment in labour, herbicide or pesticides.

An inventory carried out on 10 farms (see Box 4.2) found between 13 and 139 trees/ha protected in the fields. Farmers listed 46 different species as being actively protected in fields, but a few species are protected with much more frequency than others. These include *laurel* (*Cordia alliodora*), *caoba* (*Swietenia humilis*) and *quebracho* (*Lysiloma* spp.).

The trees which farmers protect in this way are the product of natural regeneration. It is rare for farmers to plant trees in their fields (except in fence lines, where they are generally planted as stakes), because of the risk of them being damaged by the cattle that are seasonally introduced into the fields to eat crop residues. Furthermore, the abundance of naturally regenerated

Box 4.2 On-farm tree material in Los Coyotes and Agua Zarca, southern Honduras

An inventory was carried out in 10 fields in two case study communities in southern Honduras. In each field, six sample plots, with an area of 100m² each, were inventoried. In all cases, the fields had already been cleared for cultivation, and had been sown with maize, *maicillo* or beans. None of the fields had been burnt.

Quantities of tree material found in farmers' fields (ranges of plots) in southern Honduras

	Agua Zarca (n=6)		Los Coyotes (n=4)	
	Average	Range	Average	Range
Trees/ha. (›2m height)	43	13–139	76	27–102
Stumps/ha. (‹2m height)	5,636	2,917–7,550	6,496	3,983–8,500
Seedlings/ha. (‹2m height)	4,628	1,567–10,167	1,546	1,367–1,650
Stumps+seedlings/ha.(‹2m height)	10,286	6,567–17,717	8,042	5,633–10,067
Species/plot (100m² area)		8.8–13.3		13.0–16.0
Total species found	**89**			

trees and their products in many areas makes it unnecessary for farmers to invest in planting. Most of the tree planting that has been carried out has been the result of substantial support and promotion by NGOs or rural development projects, sometimes depending on the use of incentives to motivate farmers. In some cases this has involved farmers having to suspend the practice of introducing cattle into their fields until after the trees are established. This represents a cost to farmers in the form of reduced fodder production and reduced income from rental payment.

Farmers also implement silvicultural practices such as thinning and pruning in their fields. Although they may initially protect large numbers of small trees of certain species, they will only accept a limited number of mature trees as these cast shade on their crops. As the trees develop, farmers carry out progressive thinning in order to achieve the required balance between trees and crops, concentrating on eliminating poorly formed individuals. 60% of farmers who reported maintaining trees in fields also reported pruning trees. As with thinning, this practice is used to reduce competition between trees and crops for light, and to improve tree form.

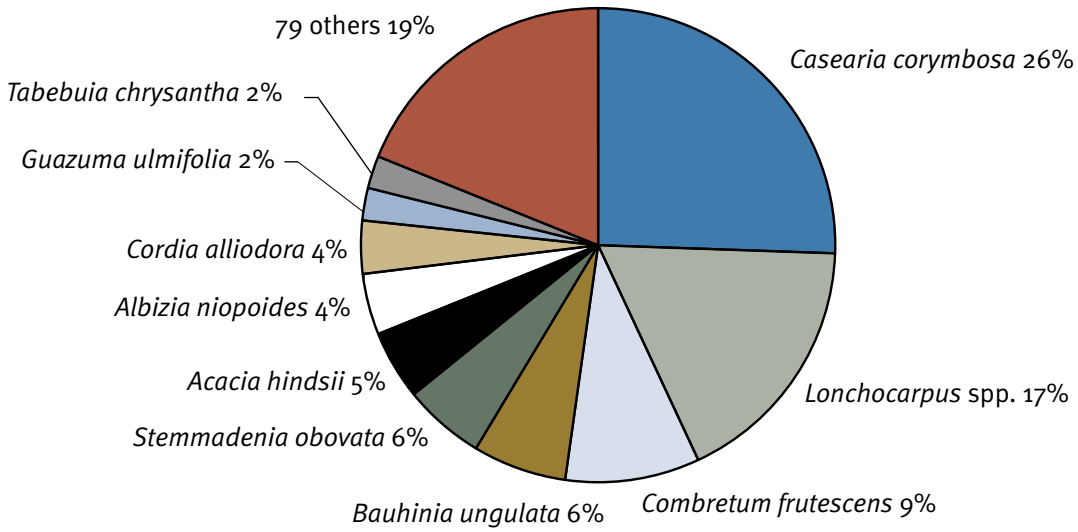
Abundant young natural regeneration in a field in Agua Zarca, southern Honduras. Between 5,633 and 11,583 individuals of tree species were found per hectare in farmers' fields. 99% of these were stumps and seedlings.

Table 4.7 Numbers of farmers reporting the active protection of different tree species in their fields in southern Honduras

Species	Farmers	% (n=79)
Laurel (*Cordia alliodora*)	30	38.0
Caoba (*Swietenia humilis*)	18	22.8
Quebracho (*Lysiloma* spp.)	16	20.2
Guanacaste (*Enterolobium cyclocarpum*)	8	10.1
Carreto (*Albizia saman)*	8	10.1
41 other species (of which 7 are exotics)	1–5 each	1.3–6.3

An important aspect of farmers' tree management practices is their relatively limited impact on those trees, which are not the object of active protection or management. In the 10 fields surveyed, an average of nearly 6,000 live stumps and 3,400 seedlings of tree and shrub species per hectare was recorded, in addition to the standing trees which were actively protected and managed by the farmers. Stumps and seedlings are profuse and of diverse species. A total of 89 species was found in the 6,000m² area sampled. A single species (*Casearia corymbosa*), however, made up more than 25% of all the individuals found, and 10 species between them accounted for more than 80% of all of the individuals (Fig. 4.2). The stumps persist in fields from one fallow period to the next, and the seedlings originate from the seed rain from neighbouring trees, or germinate from the latent soil seed bank once conditions are favourable.

Figure 4.2 Relative densities of species (seedlings, stumps and trees) in fields in two Honduran study communities



Farmer with a pruned laurel (*Cordia alliodora*) tree near Perspire, southern Honduras

The presence of so many stumps and seedlings, despite the fact that they compete with crops for space, results from farmers' limited capacities to eliminate them. Farmers are constrained by their limited labour resources, their limited economic capacity to purchase herbicides, and the steep topography which makes mechanisation difficult. Their only recourse is to resort to ineffective manual cutting by machete and, in many cases, burning.

Homegardens

In contrast to fields, the homegardens immediately around the house are typically dominated by planted trees. Here, there is little risk that they will be damaged by animals, except in those communities where homegardens are used as overnight corrals for cattle.

Trees planted in homegardens are normally allowed to develop unhindered as the shade they cast is welcome around the house. They are only felled or pruned in order to favour more valuable species, or to reduce the risk of branches falling on the house.

Fruit trees, often exotics, predominate. In some communities these are an important source of income and their proximity to the house facilitates protection and harvesting, while in others the main attraction is the ease of snacking. The homegarden is also typically used as the experimental area of the farm, where new, unfamiliar species acquired from other farmers or from extension agencies can be tried out before being planted elsewhere on the farm.

Woodlots

On-farm woodlots normally result when areas are abandoned (either permanently or temporarily). Most of the woodland areas in southern Honduras probably arose in this way. In some cases, the woodlot may be cleared again for agriculture after a number of years and another area of the farm set aside.

Woodlots are important for the production of firewood, timber and other products. The areas set aside in this way are typically the steepest and most inaccessible parts of the farm, least suited for agriculture. In some cases, however, the woodlot is deliberately left close to the house, as an easily accessible source of firewood. 29% of the farmers interviewed had an area of woodland, with an average size of 4.1ha, making up an average of 22.3% of their farms.

Conclusions: Key factors affecting how farmers use and conserve trees

The results presented above demonstrate clearly that conservation through use is a reality for many species in the agroecosystem of southern Honduras. A number of key factors can be identified as determining whether and how farmers carry out conservation through use.

Demand for tree products

Farmers' protection of trees in fields is motivated partly by their demand for tree products for subsistence uses, such as construction poles and fence posts. Where market access is good, farmers may also be motivated by the potential cash income from trees. Thus, the average number of trees found in fields in Los Coyotes (see Box 4.2), with its good access to furniture markets, was 34% higher than that in the relatively isolated community of Agua Zarca. As in Agua Zarca, opportunities for selling trees in much of the rest of southern Honduras are limited by an unfavourable legal environment, poor physical access to markets and the limited interest of the timber market for 'non-traditional' species (i.e. species other than *C. odorata*, *C. alliodora* and *S. humilis*).

Product scarcity

Farmers who protect trees in their fields do so because it is increasingly difficult to obtain them elsewhere in the landscape, and because they lack the capacity to purchase the desired products. This scarcity is to a large extent the result of the gradual reduction in the amount of fallow in the landscape, evident from time comparison of aerial photographs. Reduction in availability of valuable species is also due to over-exploitation in areas where access is poorly controlled.

It should be noted that protection as a response to scarcity is largely limited to those species which adapt easily to conditions in farmers' fields, such as *C. alliodora*. By contrast, *B. quinata* does not regenerate so easily in fields, forcing farmers in Los Coyotes, for example, to switch to more robust species, even if some of these (such as *G. ulmifolia*) have inferior product quality (see Table 4.1).

Use and tenure rights

Farmers only invest in protecting trees when they are sure that they will reap the eventual benefits. Although many farmers may lack formal title to their land, customary tenure generally provides sufficient security to motivate them to conserve trees for their future use. However, many farmers did mention worries about the government denying them harvest rights at some future date. This is a hangover of the legal situation from 1974 to 1992 when tree use rights were reserved to the State. Although this law has now been revoked, rural communities tend to be ill-informed about their legal rights, or to fear a subsequent reversal of the change.

Conversely, the Agrarian Reform Laws of the 1960s and 70s, although aimed at increasing farmers' access to land tenure, actually motivated farmers to deforest in some cases. Farmers in the community of San José de las Conchas, which was formed under the Agrarian Reform, described how they were obliged to clear trees and forests (despite their recognition of their future potential value) in order to demonstrate to the State that the land was being used productively and thereby avoid expropriation.

Many Honduran farmers, especially the land poor, cultivate on land rented from others. In this case the general rule is that rental confers no rights to extract tree products (except in some cases firewood, with the permission of the owner). Furthermore, rentals tend to be

agreed on condition that potentially valuable trees are protected. This could be described as a form of conservation through use by proxy.

Regulation

Regulation is something of a double-edged sword. On the one hand, ineffective regulation, due to weaknesses in Government institutions and a failure to decentralise controls effectively to local level, coupled with an absence of effective community-based control, contributes to the degradation of tree populations in open access areas, such as stream sides and the properties of absentee landowners. Many of the local people interviewed reported that AFE-COHDEFOR had little or no presence at community level and considered that the application of the law tended unfairly to favour people with more resources. On the other hand, farmers wishing to protect trees on their own lands are in many cases discouraged from doing so by the difficulty of obtaining the permits necessary to transport the products to market. Farmers in one community explained how they prefer to invest in cattle than trees as a form of emergency savings, because a cow can be sold from one day to the next whereas it may take weeks to get permission to sell a tree.

5. Coastal Oaxaca: Community-based conservation

Coastal Oaxaca contrasts sharply with southern Honduras, having large areas of apparently intact MTDF. Another important difference is the existence of strong community-based controls on natural resource management in some parts of the area. In this chapter we show that conservation through use is very much in evidence in the Oaxaca study area, though it operates largely at the communal, rather than individual, level, and affects both forests as a whole and individual tree species. As in the case of southern Honduras, the principal factors which determine its application include the existence of demand and markets for the products of trees and forests; the level of scarcity of these products; and the effectiveness of regulation, in this case at the community level.

Historical background

In common with southern Honduras, coastal Oaxaca in Mexico had a sizeable pre-Hispanic population. The peoples who first arrived, between 7,000 and 9,000 years ago, were nomadic hunter-gatherers who depended heavily on the forest for the collection of subsistence products. These people gradually adopted a more sedentary lifestyle, forming small villages and beginning to modify their environment, for example through the establishment of agricultural plots on alluvial terraces. Increasing population growth and social organisation then led to the formation of urban centres and the expansion of colonisation, slash-and-burn agriculture and the gathering of forest products into new areas, including low-lying coastal plains. By the time the Spanish arrived, slash-and-burn agriculture was practised throughout the area, from the lowlands to the foothills of the Sierra Madre del Sur, while irrigated agriculture had become more important near to urban centres (Rodríguez Canto, 1995).

The arrival of the Spanish resulted in a major demographic collapse, estimated at 64% between 1550 and 1650 (Rodríguez Canto, 1995). This collapse was less severe than in Honduras and many of the cultural traits of the inhabitants survived to a greater degree, including communal forms of organisation and tenure. The colonial authorities in Oaxaca eventually took some measures to ensure the survival of indigenous communities, granting them land for habitation and cultivation (Velásquez Zepeda, 1998). Colonial production systems mirrored those in much of Central America: export crops were promoted on fertile coastal lands and cattle ranching expanded elsewhere.

During the post-Independence period (1810-80), the extraction of forest resources assumed an increased importance.

Dry forest in the hills of coastal Oaxaca, with flowering *Cordia elaeagnoides*

The species extracted included Brazil wood (*Haematoxylum brasiletto*), which was used as a source of dyes, mahogany (*Swietenia humilis*) and Spanish cedar (*Cedrela odorata*). The Mexican Revolution of 1910-20 led to communal tenure and resource management structures being enshrined in the 1917 Constitution. The agrarian reform, that belatedly followed the Revolution, established communities' tenure rights over enormous areas of the country, through the establishment and formalisation of communally managed *ejidos* and agrarian communities.

Despite initiatives during the 19th century to develop the productive potential of the coastal lowlands, the region remained relatively underdeveloped until recently, due in large degree to its isolation from the city of Oaxaca, the state capital, which itself suffered economic isolation from the rest of Mexico. This situation changed in the second half of the 20th century, when trunk roads and airports improved communications with the rest of the country. The second half of the 20th century also saw important influxes of population into the area. It was in this period that several of the study communities were formed, by immigrants from deprived areas in the interior valleys of Oaxaca and indigenous areas of the Sierra Madre del Sur.

Trends in tree and forest resources

Although the forests in coastal Oaxaca have not suffered the same wholesale clearance for agriculture as has occurred in southern Honduras, the situation is far from stable. Rates of change are even harder to estimate than in Honduras as the aerial photographs available do not permit comparison over a period of several decades. Trends must therefore be inferred from the explanations offered by the farmers interviewed in the four study communities.

El Sanjón is the community in which the vegetation has undergone most change over the last 50 years. When the first of the present inhabitants arrived from nearby San Pedro Tututepec in the 1950s, taking over the lands from their earlier large landowners (*latifundistas*), the lowlands of El Sanjón were largely forested and used only for extensive grazing, with occasional agricultural clearings. Since then, the forests have been converted almost entirely to lemon plantations, sown pastures and permanent cropping areas.

Lemon trees, El Sanjón, Oaxaca

The community of Petatengo is also the product of largely local migration; most of the first arrivals were farmers from the nearby community of Santa María Xadani who previously used the area for grazing their cattle and subsequently settled there. The current inhabitants describe the area as having been entirely forested ('*puro monte*') when they arrived. Today, half of the community's land is an open grazing area, with much forest cover remaining (albeit affected by grazing), and the rest is used for agriculture with many individually-fenced plots.

Most of the present day inhabitants of El Limón migrated there from indigenous communities in the Sierra Madre del Sur over the last 50 years. There had previously been another community on the same site, hence much of the area may earlier have been cleared for agriculture and then allowed to return to fallow once the community was abandoned.

In La Jabalina, the areas currently used for agriculture were first cleared in the 1960s and then, with some exceptions, allowed to return to fallow. They were then cleared and occupied again when the present inhabitants of the community were displaced in the 1980s from their homes on the coast by the establishment of the Bahías de Huatulco tourism complex. More land was cleared by people who moved from further inland to settle along the length of the coast road when it was constructed in the 1970s. In some cases this allowed their original areas to revert to forest.

In all of the communities, farmers mentioned that certain species had become scarcer in recent years (see Table 5.1). In El Sanjón, this scarcity was attributed principally to the wholesale clearance of lowland forests for agriculture. In the other communities, the principal cause was considered to be over-exploitation of individual trees for timber and other extractive uses (e.g. *A. adstringens* (*cuachalalá* bark) and *C. odorata* (Spanish cedar) in El Limón).

Table 5.1 Species reported to have declined in abundance in the Oaxaca case study communities

El Sanjón	La Jabalina	El Limón	Petatengo
Lowlands: *Acacia farnesiana* *Astroneum* spp. *Calycophyllum candidissimum* *Enterolobium cyclocarpum* *Hymenea courbaril* *Pithecellobium dulce* *Swietenia humilis*	*Cedrela odorata* *Cordia elaeagnoides* *Guaiacum coulterii* *Swietenia humilis*	*Amphyteringium adstringens* *Casearia tomentosa* *Cedrela odorata* *Cordia elaeagnoides* *Hintonia latiflora* *Swietenia humilis*	*Andira inermis* *Tabebuia rosea* *Poeppigia procera*
Higher lands: *Comocladia engleriana*			

Smallholder agriculture today

Present day smallholder agriculture in coastal Oaxaca is similar in some respects to that practised in southern Honduras, described in the previous chapter. The principal annual crops produced in the four study communities are maize and beans; others include squash, water melon, rock melon, peanuts, chilli, tomato, sesame and Jamaica sorrel (*Hibiscus sabdariffa* L.). The importance of these minor crops varies greatly between communities.

An important contrast with southern Honduras is that significant numbers of farmers in coastal Oaxaca practise some mechanised agriculture and/or irrigate some of their crops. Mechanised

agriculture in particular has implications for the management of native vegetation as it leads to the removal of stumps and the permanent cultivation of plots, rather than cyclical fallowing and cultivation. However, more than 70% of interviewees did report fallowing their land. Another important difference between the two study areas is that, whereas cattle in southern Honduras are largely enclosed, much of the livestock in the Oaxaca study communities (particularly goats and sheep) grazes freely in open access areas.

The frequency of these different practices varies widely between communities (Table 5.2). El Sanjón stands out as having markedly different production systems to the other three communities. The flat coastal lands which make up a large proportion of its area have been almost completely cleared and destumped and are now dominated by plantations of lemons, which are sold to nearby markets and provide an important source of income.

Table 5.2 Frequency of different agricultural practices in case study communities in coastal Oaxaca

Case study community	% of farmers practising mechanised agriculture	% of farmers irrigating their land	% of farmers who fallow their land	Average length of fallow (years)	% of farmers with livestock		
					Cattle	*Goats*	*Sheep*
El Sanjón	81	68	50	3.0	25	15	0
Petatengo	52	0	50	3.5	30	30	20
El Limón	0	50	94	11.5	0	15	15
La Jabalina	10	22	93	3.4	40	5	0

Institutional environment

In Mexico, the institutional framework for conservation initiatives is a complex one, characterised by many actors, both government and non-government, at multiple levels. With as much as 80% of Mexico's forest in the hands of *ejidos* and indigenous communities (Bray et al., 2005), communal action is an important feature of local level resource management.

Government

Three levels of government are provided for in the Constitution of the Mexican Republic: federal, state and municipal. At the federal level, the two key ministries of relevance to conservation and rural development, respectively, are the Secretariat of Environment and Natural Resources (SEMARNAT) and the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), both of which have delegations at state level. SEMARNAT includes the National Commission for Protected Natural Areas (CONANP), the National Forestry Commission (CONAFOR), the National Water Commission and the National Ecology Institute (INE). These secretariats and their dependencies are responsible for policy formulation, regulation

and the implementation of projects and programmes.[8] The Minister of SEMARNAT is also Technical Secretary of the multi-sector National Commission for Biodiversity (CONABIO).

The Federal Government has implemented a number of important programmes related to agricultural productivity and agrarian reform; including PROCAMPO, aimed at promoting and stabilising agricultural production through the provision of incentives; PROCEDE, aimed at formalising communities' tenure rights; and the National Micro-Watersheds Plan, implemented by SAGARPA through the Shared Risk Trust Fund FIRCO.

Initiatives sponsored by the Federal Government have had something of a chequered history in the coast region. Most notable has been the expropriation of large areas of communal land in the municipality of Santa María Huatulco by the National Tourism Fund FONATUR. As described in Box 5.2, this exacerbated mistrust among local communities in relation to the establishment of a Federal National Park in the same municipality.

There is interest among state governments to achieve increased decentralisation of responsibilities, including the management of natural resources. This has led them to promote their own conservation initiatives as an alternative to those promoted by federal entities such as SEMARNAT. The Oaxaca State Ecological Institute, for example, parallels the federal INE, and there are moves to establish a system of protected areas at state level.

Within municipal governments there exist *regidores ecológicos* charged with environmental issues. These tend to be largely political posts, however, and in general the role of municipalities in relation to environmental issues is frequently limited to urban areas. They do, however, have an important role as the focal point for government funded initiatives in both conservation and rural development, such as the National Micro-Watershed Plan coordinated through SAGARPA.

NGOs

There is a great diversity of NGOs in Oaxaca, working at varying scales to promote conservation and rural development in the coastal region. Their main focal point is the city of Oaxaca itself, although there are a number based in the coast region.

Several initiatives have sought to promote dialogue and coordination between the many NGOs. These include the Oaxacan Commission for Ecological Defence (CODE) and, most notably, the Oaxaca Programme of the WWF, the latter having had an important role in the conception and early development of several conservation orientated organisations (Gordon, 2006). These initiatives have contributed significantly to communication between NGOs, although notable differences of approach remain. Some conservation and rural development NGOs focus strongly on grassroots participatory approaches, in contrast with the more centralised approaches of some government institutions.

8. The conversion of SEMARNAP to SEMARNAT under the Government of President Fox was accompanied by a considerable degree of decentralisation, and a reduction in the relative role of the institution in the implementation of projects and programmes.

The WWF has also functioned as an important conduit of funding from sources such as the European Union and the UK National Lottery. In general, NGO activity in Oaxaca is heavily dependent on external funding, both international (e.g. from the Ford Foundation and MacArthur Foundation) and national, as in the case of the Mexican Fund for Nature Conservation (FMCN). The reduction of SEMARNAT's implementation role has also opened further opportunities for these NGOs to implement government-funded projects.

Community structures for management and conservation

In much of the coastal region, there is a high level of organisation at community level. The four case-study communities (see Chapter 3) illustrate the different organisational structures provided for in the 1917 Mexican Constitution, and demonstrate their functioning and varying degrees of effectiveness under a range of conditions.

In all of the study communities, two parallel structures exist: the municipal government and the agrarian authorities. The physical boundaries of the jurisdictions of these two entities do not generally coincide. In some cases, the agrarian unit may be approximately equivalent in scale to a municipality but in others a municipality may overlap with a number of agrarian units.

Agrarian authorities are principally concerned with agrarian and natural resource issues. The highest decision-making body to which agrarian authorities respond is the assembly of the members of the community. Decisions are taken by vote, a simple majority being necessary to approve or reject a motion.

In *ejidos* (such as the El Limón study community), only the *ejidatarios* (formal members of the *ejido*, all of whom are men) have the right to a voice in the assembly; *avecindados* (people allowed to reside in the community without formal tenure rights) are excluded. In the Petatengo study community, while all men over the age of 18 have a vote, women can only vote if they are single or widowed.

Policy and legislative environment

The communal forms of management that survived the Spanish conquest were undermined by the Liberal reforms of the late 19th century. However, the Mexican Revolution and the ensuing 1917 Constitution provided the basis for the agrarian reform, the communal territorial units (agrarian communities and *ejidos*) and the administrative structures on which today's communal organisation, tenure and management are based. In 1992, neo-liberal desires to achieve increased efficiency in the rural sector by promoting individual tenure and land management patterns led to the modification of the Constitution in 1992 and a new Agrarian Law. This, for the first time, allowed *ejidatarios* to sell their land, and saw the implementation of incentive schemes such as PROCAMPO, which require beneficiaries to demonstrate continuous occupancy of fixed plots of land.

In practice, such moves at legislative and policy level to promote private tenure appear to have had relatively limited implications for communally-based regulation and management. For the time-being, few *ejidatarios* have taken advantage of the amendment and sold their

land. A more significant influence on both *ejidos* and agrarian communities appears to be the informal privatisation of tenure through the fencing off of communal lands for individual use.

At the same time, the last two decades have seen an increasing legal recognition of communities' rights to manage their natural resources in a decentralised and autonomous manner. Most notable have been the two Forest Laws of 1986 and 1997, the LGEEPA (*Ley General de Equilibrio Ecológico y Protección del Ambiente*) of 1996 and, at the international level, Treaty 169 of the International Labour Organisation regarding the rights of indigenous communities.

How farmers use trees and forests

The range of different uses and benefits obtained from trees and forests listed by the informants in coastal Oaxaca (Table 5.3) is as diverse as that reported for southern Honduras (Box 4.1). A number of these products are commercialised, for example, baskets made from *carrizo* (a type of bamboo), the bark of *cuachalalá* (*Amphyteringium adstringens*), furniture made from *ocotillo* or *grisinia* (*Cordia elaeagnoides*), and firewood from *palo de arco* (*Apoplanesia paniculata*).

Of the uses and benefits mentioned in Table 5.3, the majority are obtained from individual trees, either within the forest or in the agricultural landscape. Only four of those mentioned depend on the existence of the vegetation in general (hunting, soil fertility restoration, ecotourism and iguana raising). In addition to benefits, farmers also mentioned a number of disadvantages and problems caused by trees (Table 5.4).

A farmer in El Limón, Oaxaca, holding the bark of *cuachalalá* (*Amphyteringium adstringens*) sold for its medicinal properties

Species preferences

Farmers mentioned 56 different species used for firewood, 97 for timber and 31 for medicines, out of a total of 448 tree and shrub species recorded by the botanical survey. Table 5.5 lists the most commonly reported firewood and timber species. As is the case in Honduras, the species used vary widely between communities: 79% of firewood species and 75% of timber species were only reported as being used for these purposes in one community. Only three out of 97 timber species (*Calycophyllum candidissimum, Enterolobium cyclocarpum* and *Swietenia humilis*) were used in all four communities. Only in El Sanjón, where extensive plantations of lemons and coconuts exist, were lemons (*Citrus* spp.) and coconuts (*Cocos nucifera*) reported as being used for either timber or firewood.

Table 5.3 Examples of uses and benefits obtained from trees in coastal Oaxaca

Use	Examples of species used
Timber	Various species, see Table 5.5 for detail
Firewood	Various species, see Table 5.5 for detail
Posts	Various species
Tools	*Tabebuia rosea*
Furniture	*Cordia elaeagnoides*
Fruit	*Mangifera indica, Byrsonima crassifolia, Spondias mombin, Leucaena esculenta, Tamarindus indica*
Forage	*Cordia dentata, Guazuma ulmifolia*
Hunting	The forest as a whole
Medicine	Various species
Soap	*Thouinidium decandrum, Coccoloba* spp.
Baskets	*Bambusa* spp.
Brooms	*Xoyamiche* palm
Soil fertility restoration	Fallow vegetation in general
Demarcation of boundaries	*Mangifera indica*
Roosting places for chickens	*Mimosa tenuiflora, Gliricidia sepium*
Poles for harvesting lemons	*Guazuma ulmifolia*
Roofing	Palms, coconuts, straw
Ecotourism	The forest as a whole
Washboards	*Cordia dentata*
Dyes	*Haematoxylon brasiletto*
Medicine for animals	*Cochlospermum vitifolium*
Kindling	*Haematoxylon brasiletto*
Mills for grinding grain	*Hymenea courbaril*
Iguana raising	Small woodlands

Table 5.4 Disadvantages and problems of trees mentioned by farmers in coastal Oaxaca

Problem	Situation or Species
Agriculture	
Interference with agricultural machinery	In lemon orchards and other cultivated lands e.g. *Enterolobium cyclocarpum*
Thorns make manual work difficult	In agricultural plots e.g. *Acacia collinsii*
Shade (competition for light with crops)	Agricultural plots and lemon orchards e.g. *Pithecellobium dulce*
Shade (competition for light with pasture)	In pastures
Yellowing of crops	*Gliricidia sepium*
In homegardens	
Shade (competition for light with other trees)	e.g. *Enterolobium cyclocarpum*, *Muntingia calabura*
Threat of falling on the house	e.g. *Gliricidia sepium*, *Enterolobium cyclocarpum*
Excessive production of flowers and leaves	e.g. *Tabebuia rosea*, *Ipomoea wolcottiana*
Health	
Toxic or irritating properties	e.g. *Ficus* spp., *Comocladia engleriana*

Table 5.5 Species most reported as used for firewood and timber in Oaxaca case study communities

Firewood	Timber
1. *Hesperalbizia occidentalis* 2. *Apolplanesia paniculata* 2. *Gliricidia sepium* 4. *Citrus* spp. 5. *Guazuma ulmifolia* 6. *Acacia collinsii/hindsii* 6. *Cordia alliodora* 8. *Acacia cochliacantha* 9. *Acacia farnesiana* 10. *Cocos nucifera*	1. *Cordia elaeagnoides* 2.*Comocladia engleriana* 2.*Hesperalbizia occidentalis* 4.*Cordia alliodora* 5. *Enterolobium cyclocarpum* 6. *Gliricidia sepium* 7. *Apoplanesia paniculata* 7. *Cocos nucifera* 9. *Calycophyllum candidissimum* 10. *Tabebuia rosea*

Sources of tree products

In contrast with southern Honduras, most farm families in the Oaxaca study area obtain their tree products from communal land that can be freely accessed by all community members, rather than from their own plots (Table 5.6).

Table 5.6 Sources of firewood and timber reported by farmers in Oaxaca case study communities

Source	% of farmers (n=80)	
	Firewood	Timber
Communal land	62.5	53.8
Homegardens	30.0	3.8
Agricultural plots	18.8	16.3
Pastures	0	1.3
Others' land	5	3.8
Purchase	3.8	10.0

El Sanjón, with its extensive commercial plantations, differs markedly from the other communities studied, with respect to where its inhabitants obtain tree products. Only three interviewees in El Sanjón (15%) reported obtaining timber from communal lands compared to an average of 67% of informants in the other three communities, while six people in El Sanjón reported purchasing timber compared to only two in Petatengo and none in either of the other two communities.

Protection and management of trees and forests

Tree planting

All of the farmers interviewed said that they had planted trees at some time or other. However, this activity is concentrated in farmers' homegardens (*solares*).[9] 99% of farmers reported having planted trees in their home gardens, whereas only 22% had done so in their cropping areas. A total of 95 different species were reported as having been planted in homegardens, compared to only 17 in cropping areas. The top 10 species planted in homegardens are all fruit trees, of which only three are native (*Spondias mombin, Leucaena esculenta* and *Byrsonima crassifolia*). Only 22% of the species planted in homegardens were reported as being used for timber and 13% for firewood. In cropping areas, 9 of the 17 planted species were reported as being used for timber (principally *Gliricidia sepium*, *Swietenia humilis* and *Tabebuia rosea*).

9. As in southern Honduras, *solares* in the Oaxaca study communities are highly variable in nature and tend to be defined principally by their proximity to the house.

In Petatengo, community members have been encouraged by a local NGO to carry out enrichment planting in communal forests (see Box 5.1). This reforestation is intended to increase the commercial value of the forest, both in terms of direct products for the community and of hydrological services for downstream neighbours, thus increasing the community's incentive to conserve it.

Tree planting commonly involves movement of tree material between communities, and between different parts of the same community, in the form of seed, transplanted natural regeneration, or live posts or branches for planting as stakes. In El Sanjón, which consists of an upper area of staple grain production with some secondary forest and fallows, and a lower area with houses and commercial lemon plantations, the downward movement of tree material is dominated by timber species collected in the upper forests and fallows, and the upward movement by fruit trees (mostly exotics), medicinal plants and ornamentals collected in lowland homegardens. Inter-community movement of germplasm is generally based around family relations, and is also dominated by fruit trees, ornamentals and medicinal plants.

Box 5.1 Commercial extraction and reforestation in communal lands in Petatengo

The NGO, *Centro de Soporte Ecológico* (CSE), has promoted the marketing of timber and other tree products from communal areas of Santa María Petatengo, with the aim of generating income for the community and thereby increase local peoples' motivation to conserve their forest resources. At the same time, CSE has also promoted reforestation to balance the extraction and enrich the resource. One of the principal motivations for the project has been the perceived threat to the future water supplies of the nearby tourist centre of Bahías de Huatulco, posed by deforestation inland (Barkin and Paillés, 1998). It is hoped that the community will be paid for protecting the forest's hydrological services.

The processing and marketing activities focus on the utilisation of currently undervalued material (because of its small diameter or species, e.g. *Bursera* spp.), for the production of turnery, cellulose for hand-made paper, and handicrafts. The aim is that "technological innovations associated with existing market opportunities will allow wood products rather than raw trees to be marketed, with more employment and value accruing to the communities;....these communities have suffered from unfavourable conditions for their products for decades....as the market works to exacerbate the discrimination imposed by society against indigenous groups and peasants, placing a low value on their labour and the products of their work" (Barkin and Paillés, 1998).

CSE has held more than 70 consultation and planning meetings with the community. Concerns about individuals gaining commercial benefit from naturally-regenerated trees in communal lands have led to the decision that the whole area will be managed communally and benefits will be distributed equally among the population as a whole.

The reforestation is principally in the form of enrichment planting underneath the canopy of existing forest in the communal grazing area (*agostadero*), using plants of native species raised in two communal nurseries from locally-collected seed. By the end of 1999 around 600,000 trees had been planted (Paillés, C., pers. comm., 2000). The programme encountered some opposition from larger ranchers, concerned that reforestation activities in the *agostadero* would lead to restrictions on grazing. Other community members were fearful for the community's tenure over the reforested lands.

Protection of trees by individuals

Active protection of trees is concentrated in the homegardens, where it focuses on planted, rather than naturally regenerated trees. This protection consists principally of fencing in order to avoid trees being browsed by animals. The way this is arranged varies widely between communities. In El Sanjón, for example, a single fence may enclose several houses and home gardens, while, in Petatengo, valued plants are established within a small fenced area in each homegarden.

In contrast to southern Honduras, trees in cropping areas rarely receive active protection. In only one of the four communities, Petatengo, was this reported, largely in response to motivation by an NGO. One of the participating farmers in this community described how "previously vegetation was uniformly cleared, but now a number of farmers leave trees for timber and the house [firewood]; they do not interfere with crops as they grow straight".

Trees are also protected through unwritten rules governing the relations between individuals. These apply principally to areas where communally owned lands have been enclosed for individual use. In El Limón, for example, it is necessary to ask the permission of an *ejidatario* (community member) and make a small payment in order to be able to fell a tree within his enclosure.

Silvicultural management

The principal forms of silvicultural management are irrigation and pruning branches. Both practices, but particularly irrigation, are more frequent in homegardens than in cropping areas. Some farmers mentioned the availability of water for irrigation as a prerequisite for planting trees. The main objective of pruning is to reduce some of the negative effects of trees, such as competition with other trees, the production of excessive quantities of fallen leaves and the risk of branches falling on the house. In the cropping areas, negative effects are normally overcome by simply eliminating the trees in question.

Community-based protection

In all of the study communities, formal controls exist (at least in theory) at community level on the felling of trees for timber and the clearance of forest areas. In El Limón, for example, the community assembly introduced a prohibition on the felling of Spanish cedar (*Cedrela odorata*) and restrictions on the extraction of the bark of *cuachalalá* (*Amphyteringium adstringens*), because of concerns over their local over-exploitation.[10] However, in practice, each community member is largely free to fell trees within their own plots and will only be fined if they fell trees outside of the communal territory, in order to avoid conflicts with neighbouring communities.

In Petatengo, the communal assembly has restricted the issue of permits for felling *guanacastle* (*Enterolobium cyclocarpum*) or *macuil* (*Tabebuia rosea*). In contrast to El Limón, the controls in Petatengo are generally well respected.

10. Across the study area as a whole, *A. adstringens* is a common and freely regenerating species, whose conservation status gives no cause for concern from the global perspective.

Only in El Limón were community controls over the collection of firewood mentioned. These norms specify where it can be collected (not too close to the urban centre) and prohibit the cutting of live trees for firewood. In Petatengo, firewood collection is regulated by agreements between individuals: it may not be removed from enclosures without the permission of their 'owners'.

Among the most effective communally-based controls encountered were those in Santa María Huatulco. In order to protect areas of forest for ecotourism, the agrarian authority (*comisariado de bienes comunales*) introduced a restriction on the felling of high forest ('*monte grueso*' or '*montaña*') for the establishment of agricultural plots. Particularly significant is the establishment of communally-managed protected areas (see Box 5.2).

The use of fire to prepare agricultural plots is also subject to community based controls in order to reduce the risk of it spreading to forest areas. In La Jabalina, the *comisariado* of Santa María Huatulco has imposed a complete ban on burning. In Petatengo, the assembly decided to permit burning only in the cooler afternoons and, if a fire escapes, the person responsible is fined in proportion to the area burnt and the damage caused.

Box 5.2 Communal and Federal Reserves in Santa María Huatulco

For a number of years federal authorities have planned to declare a federal reserve (national park) on some of the better conserved areas of Santa María Huatulco municipality, and of the area expropriated by the National Tourism Fund FONATUR for the Bahías de Huatulco hotel complex in the 1980s. This proposal was strongly opposed by local communities, which, through their agrarian authority, established 'Communal Forestry and Fauna Reserves' as an alternative. When the Huatulco National Park was established in 1999, it covered approximately 6,000ha of the onshore part of the expropriated area in addition to protected coastal waters.

The Communal Reserves today cover some 15-20,000ha, equivalent to around 35% of the communal lands of Santa María Huatulco. In these areas, the use and management of natural resources is regulated, and the clearance of forest and commercial hunting are prohibited. A number of entry points are marked by signs and are chained or gated.

A Consultative Committee has been established by the agrarian authority, the municipal authorities and with the initial support of the local NGO GAIA in Santa María Huatulco, which advises on decisions relating to the community's natural resources. A heritage fund has been established, which includes the trust fund established as compensation for the land expropriation of the 1980s. It is intended to use this for development and conservation activities.

The interest of the local communities in establishing the reserves is motivated in part by the potential for revenue generation from ecotourism, given the proximity of the Bahías de Huatulco hotel complex. A number of ecotourism operators (mostly outsiders) currently run day tours to the reserve from the hotel complex. Communally managed protected areas in Mexico are now eligible for federal support through CONANP, just as National Parks are. The long-term effect of this on communal reserves in Santa María Huatulco has yet to be clarified. However, at present, the benefits are mostly concentrated in the hands of outsiders or a few wealthier families. It has been proposed that fees be introduced for outside researchers who wish to work in the area.

Attempts to control extraction of non-timber forest products (NTFPs) have been made in El Limón, where the medicinal *cuachalalá* bark (*Amphiteryngium adstringens*) is harvested for sale in towns such as Tehuantepec and Juchitán. The existence of good markets leads to high levels of extraction. Instead of removing small quantities of bark, as happens in communities where it is only gathered for subsistence use, whole trees are typically felled in order to obtain sufficient quantities for sale. The assembly has recommended modifying extraction practices in order to prevent over-exploitation. However, the recommendation appears to have had little effect because of the economic importance of the sale of *cuachalalá* bark for local people and the fact that in this community the authorities have little say over members' activities in their individual plots. In La Jabalina, the agrarian authority has prohibited hunting for commercial purposes, and has established closed seasons for the hunting of certain animals such as iguanas and deer.

Conclusions: Key factors affecting the conservation and use of trees and forests

In contrast to southern Honduras, the examples of conservation through use found in Oaxaca largely operate at the community, rather than individual, level. There was relatively little evidence of individual farmers conserving individual trees because of their perceived utility, with the significant exception of trees being planted in homegardens as a source of fruit (and most of these are exotics). Community-based CTU was evident at both species and ecosystem levels. Examples of the former include the decrees by the communal authorities in El Limón restricting the extraction of bark from *A. adstringens*. The most notable example of the latter is the establishment of communally owned and managed reserves in Santa María Huatulco (which includes La Jabalina community). Three factors appear to be key in determining whether and how farmers carry out conservation through use.

Demand and markets

The continuing conservation of communal forests in Santa María Huatulco (Box 5.2) is partly motivated by perceptions of a demand for ecotourism and hydrological services, because of the presence in the nearby Bahías de Huatulco hotel complex of a consumer population with significant capacity to pay for these services. In practice, the functioning of the CTU mechanism is currently limited by poorly-operating markets; much of the ecotourism revenue goes to external operators because mechanisms to compensate community members for their watershed protection activities are not yet functional.

In the case of El Limón, the existence of markets for tree products (such as the bark of *A. adstringens*) is leading instead to resource degradation. *A. adstringens* was reported as occurring, and being valued, in all of the other study communities; however it was only in El Limón, with its ready access to markets for medicinal products in the Isthmus of Tehuantepec, that problems were reported with the sustainability of its use.

In El Sanjón, by contrast, it is a lack of demand for the products of native trees that is partly responsible for local people's limited interest in protecting tree populations. The relatively ready access members of this community have to cash income, through the sale of lemons or off-farm employment, enables them to purchase building materials rather than depend

on obtaining them from naturally regenerated trees. Their dependence on native trees is further reduced by the ability of the lemon and coconut plantations, which dominate much of the landscape, to provide the required tree products (firewood and building materials respectively).

The significance of demand for tree products in influencing the occurrence of CTU must also be seen in comparison with other sources of income generation. In El Sanjón, for example, lemon production on the easily cultivable flat lands offers an attractive alternative to the sale of the products of naturally-regenerated trees.

Product scarcity

The contrast between southern Honduras and much of the Oaxaca study area is striking, in terms of the relatively large amount of forest and fallow present in the latter. The ready availability of tree products from communal lands in the Oaxaca study area, in most cases removes the motivation for individual farmers to protect trees within their fields, where they are considered to interfere with crop development.

Nevertheless, actual or potential scarcity is the justification for the restrictions imposed by the communal authorities in El Limón and Petatengo on the extraction of *A. adstringens*, *C. odorata*, *E. cyclocarpum* and *T. rosea*. This scarcity is largely due to the existence of high levels of demand for the products of these species.

Community regulation

In situations where individuals' perceptions of resource values are not sufficient to protect values of importance to the community as a whole, it may be necessary for the community to regulate the actions of individuals in order to bring about conservation. The relatively effective protection of trees and forests in La Jabalina and Petatengo, in response to community-level perceptions of their use value, is largely a function of the well-developed and respected community-based regulation that exists there. In Santa María Huatulco this has permitted the establishment of large communal reserves; in Petatengo, in addition to controls on the harvesting of particular tree species, it has enabled the definition and enforcement of a system of land-use zoning aimed at minimising conflicts between livestock and agriculture.

This contrasts with the situations in El Limón and El Sanjón, in both of which tree and forest resources have suffered significant degradation (although in El Limón significant areas of forest still remain). In El Limón, the effectiveness of controls on the extraction of *A. adstringens* bark has been undermined by the attractiveness in the short term of exploiting the resource to the maximum. On the flat lands of El Sanjón, the clearance of trees is subject to little regulation, largely because of their limited use value relative to alternative land uses.

Another factor, which appears to influence the effectiveness of regulation, is land tenure. There is a progressive tendency in much of the study area towards the claim of exclusive use rights by individuals over areas of community land. The proportions of community lands affected by this process vary widely between communities. This *de facto* 'privatisation' of land tends to limit the effectiveness and relevance of community-based regulatory structures, whose

main role, under the provisions of the agrarian legislation, is the administration and defence of community resources. An extreme example of this, among the study communities, is the situation in El Sanjón, where almost all land is individually managed and community-level controls over individuals' management of their land are limited. Similarly, the designated community members (*ejidatarios*) in El Limón are largely left to their own devices within their individual plots. In La Jabalina and Petatengo, by contrast, large areas of common land remain and community controls remain strong. Conversely, the lack of individual tenure was one of the reasons farmers gave for not planting trees.

6. Global conservation priorities in the MTDF

In this chapter we draw on our botanical survey results to respond to our second research question relating to which MTDF tree species and sites should be the prime focus of conservation action. While many tree and shrub species of global conservation concern were found in coastal Oaxaca, none were found in the Honduran sample sites. In coastal Oaxaca, forest fallows were found to be an important location for conservation priority species, suggesting that current land-use practices have much to offer conservation initiatives.[11]

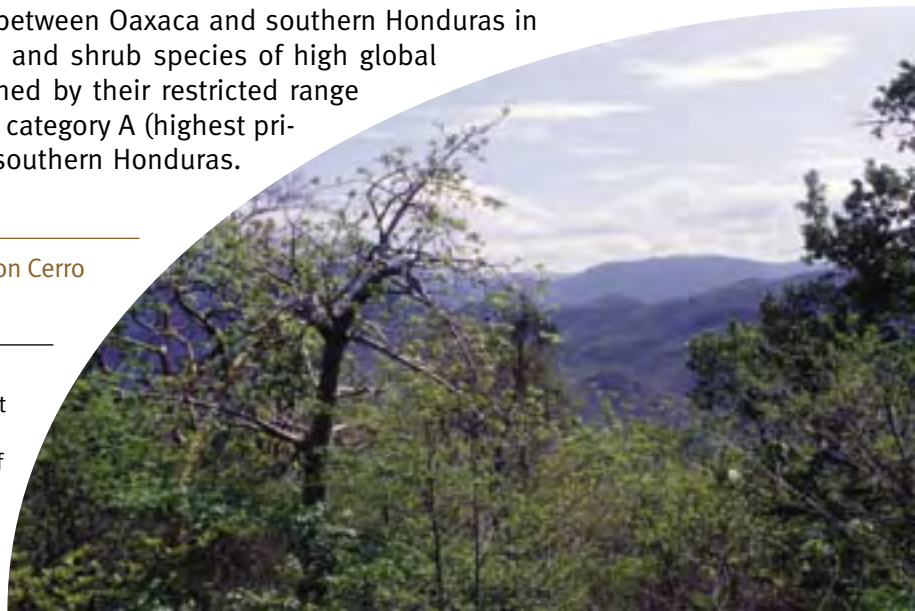
Species of conservation concern

In the course of the botanical fieldwork in southern Honduras and Oaxaca, we found and identified 594 species including many exotics, some that would not normally be considered trees or shrubs and species from transition forests around MTDF. A full list of these species is given in Appendix 4. As outlined in Chapter 3, the species were grouped into four conservation priority categories. Across the two study sites, a total of 78 species are considered to be of conservation concern (Categories A, B or C in Table 3.3) because of their restricted ranges.[12] Of these, 17 are endemic to the Pacific dry forest zone of Honduras or Oaxaca and are therefore classified as Category A (highest conservation concern).

In addition, three species were found that were not classified as category A, B or C, but are listed by IUCN as 'vulnerable' (*Bombacopsis quinata* and *Swietenia humilis*) or 'endangered' (*Guaiacum sanctum*). Two of these (*G. sanctum* and *S. humilis*), as well as *S. macrophylla*, are also listed under CITES II for international trade (but see Box 6.1). This highlights the different outcomes (in terms of conservation actions) that can arise through use of different assessment methods. The rapid botanical survey presented here, in which threat status of individual species was based on their global ranges, is relatively fine-grained and provides a useful tool to identify truly threatened species.

Location of the priority species

There is a striking difference between Oaxaca and southern Honduras in terms of the numbers of tree and shrub species of high global conservation priority, as defined by their restricted range (Fig. 6.1). This study found no category A (highest priority rating) species at all in southern Honduras.



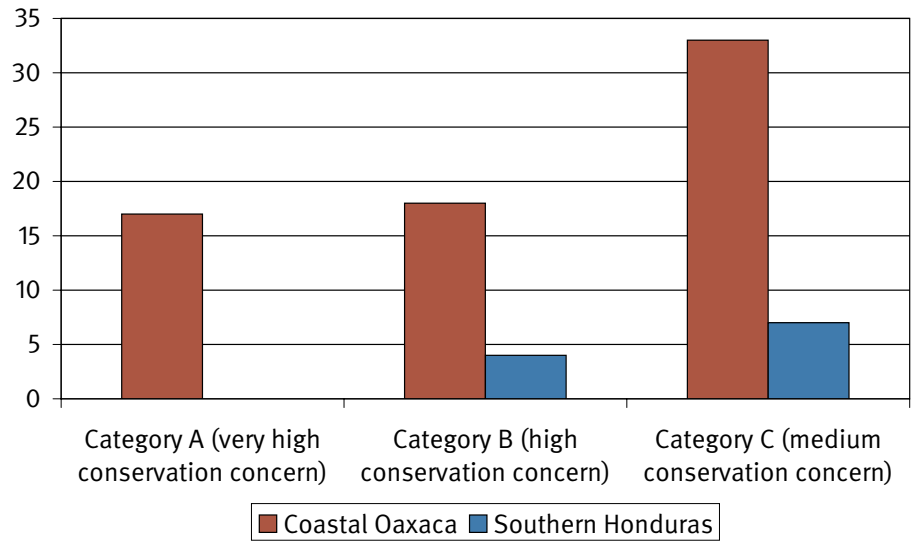
High bioquality deciduous forest on Cerro Guiengola, Oaxaca

11. The results in this chapter are discussed in more depth in Gordon et al., 2004.
12. Appendix 2 and 3 list the species of conservation concern in Oaxaca and southern Honduras respectively.

Box 6.1 *Swietenia humilis* – threatened or not?

In spite of the conservation concern suggested by the description of *S. humilis* (Honduras or small leaf mahogany) as 'vulnerable' by IUCN and its listing on appendix II of CITES, it was one of the most frequently encountered species in southern Honduras. It occurred in 51% of all samples and is well represented in all land uses except coffee plantations. The locally high timber value of this species means that farmers actively protect seedlings and saplings until they reach a size suitable for harvesting timber. This combined with its natural affinity for disturbance suggests that *S. humilis* will continue to persist in this landscape (Boshier et al., 2004). This leads us to question the assumption that felling a species for its timber is necessarily detrimental to the species' chance of survival. This assumption, in relation to international markets, is implicit in the listing of *S. humilis* in appendix II of CITES. Given also that it is of wide natural distribution, it might be that its status as an internationally protected species needs reappraising (Gordon et al., 2003).

Figure 6.1 Numbers of high conservation priority (restricted range) species in the two study areas



It should be noted, however, that the presence of such species should not be ruled out, as the present study only covered a sample of the area and did not include several dry interior valleys where rarity and endemism might be greater. Nonetheless, the consistently higher relative content of restricted range species found in the surveys carried out in Oaxaca, when compared to those carried out in Honduras, suggests that Oaxaca's MTDF is of greater global importance for the conservation of threatened tree diversity than that of Honduras.

Each of the botanical sample sites was allocated a Genetic Heat Index (GHI) value based on the numbers of high conservation priority species which it contained.[13] The results are illustrated in Figure 6.2 and reveal great variation in the numbers of high priority species between different land uses and sites. Perhaps not surprisingly, the least disturbed mature forest fragments of Oaxaca, together with some associated fallows, contain particularly large numbers of species of high global priority. The most obviously important area is the coastal belt of Oaxaca, between Huatulco and the western end of the Isthmus of Tehuantepec. Within this belt, four areas particularly stand out:

- Extensive tracts of mature deciduous forest on the coastal plain
- Deciduous forest on the steep hill of Cerro Guiengola
- Deciduous beach front forest
- Semi-deciduous forest on the steep hill of Cerro Huatulco

That sites such as Cerro Guiengola and Cerro Huatulco have well conserved forests is not unexpected. Their steep topography has protected both these hills from recent human activity. That this was not always the case, however, is evident from the precolombian ruin on Cerro Guiengola, which currently affords it further protection as an archaeological site. Cerro Huatulco too, is protected, as a Communally Managed Protected Area because of its importance as a source of water for the town of Santa Maria Huatulco. The beach front forest with its rocky slopes has also not been a site suited to intensive human activity – this is changing, however, as more tourists and more tourism development encroach upon unprotected parts of the coast.

Coastal plain dry forest, Oaxaca

Deciduous beach front forest, Bahías de Huatulco, Oaxaca

Also notable in Oaxaca, and most interesting from a CTU perspective, is the large number of high priority species in a number of non-forest sites, located near areas of mature forest. Examples of such sites were found in the study communities of La Jabalina (close to the mature forests of Huatulco) and El Limón (close to Cerro Guiengola). This suggests that the communal forms of land ownership and management in this area may play an important role in facilitating their protection. Key elements include the long forest fallows that are an integral part of the land use system and the communal awareness of the collective importance

13. Appendix 1 provides details of how GHI is determined.

of natural resources that has led, for example, to the creation of a Communally Managed Protected Area in part of the forest around La Jabalina (Gordon et al., 2004).

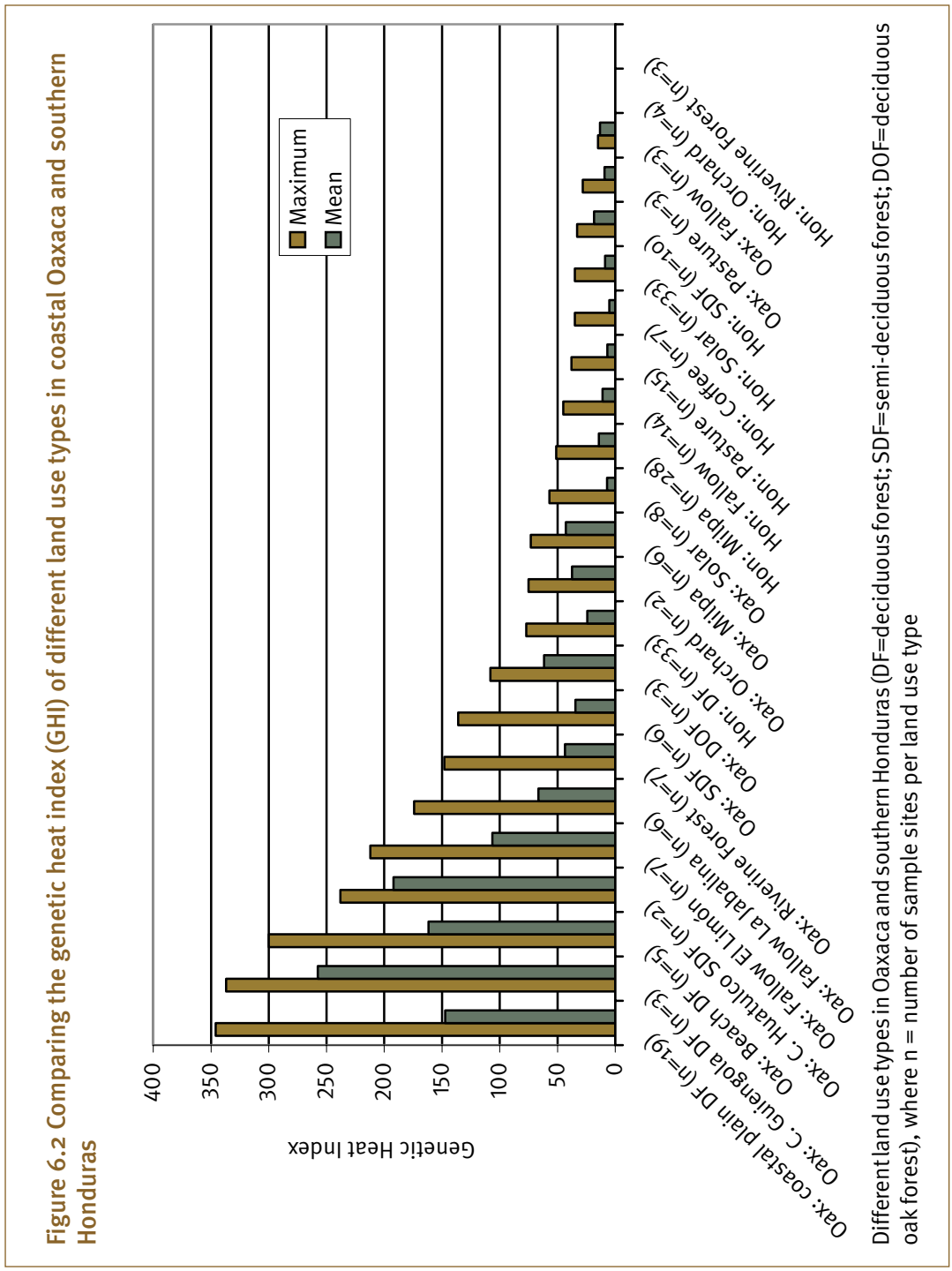


Figure 6.2 Comparing the genetic heat index (GHI) of different land use types in coastal Oaxaca and southern Honduras

Different land use types in Oaxaca and southern Honduras (DF=deciduous forest; SDF=semi-deciduous forest; DOF=deciduous oak forest), where n = number of sample sites per land use type

The limited numbers of high global priority species in southern Honduras mean that this region has few, if any, sites or land uses of high global priority for the conservation of tree species diversity. In spite of extensive conversion of the original forest, this agroecosystem nevertheless plays an important role in conserving a large number of woody species, including many category B and C species, at little or no cost to conservation programmes. Our findings indicate that these species occur equally in all forms of land use (except homegardens, which are typically dominated by exotic fruit trees), as might be expected given the role of natural regeneration in determining tree species composition. The lack of land use specificity shown by these species, along with limited evidence that gene flow can be maintained between their fragmented populations (White and Boshier, 2000), suggests that they may continue to be conserved as long as land management practices continue to favour natural regeneration (Gordon et al., 2003).

Fragmentation, corridors and connectivity

Conservation biologists are concerned that, in the long term, the patches of forest left in typically fragmented dry forest landscapes may not, individually, be capable of sustaining all of the organisms they contain (Whittaker, 1998). One reason for this is that isolated populations are unlikely to contain all of the genetic variability of larger populations, reducing their ability to adapt to pests, diseases and other negative changes. Another reason is that unpredictable events, such as fires or pest outbreaks, may easily remove all of the individuals of a species from a small patch into which it is unlikely that it will be reintroduced through natural processes of dispersal because of its isolation from other sub-populations of the species. These fragmentation effects are especially severe in tropical ecosystems, where the existence of large numbers of different species means that most species are each only represented by a limited number of individuals. The fragmentation of Mesoamerican dry forest is particularly acute, increasing the risk of local species extinctions.

To mitigate the negative effects of fragmentation, much attention has been paid to the role that biological corridors might have in connecting fragments of forest and increasing their effective size. A biological corridor is typically visualised as a narrow band of habitat, similar in structure to two areas of conservation concern, which it connects. Our research indicates that the tree and shrub vegetation that grows up following clearance, in the areas surrounding surviving forest remnants, is in many cases of comparable species composition to the forest itself. Such areas, particularly (but not only) forest fallows, could therefore serve as connectors between more intact conservation areas. The typically mosaic-like nature of land use, in the agricultural landscapes where management involves the successive clearance and re-growth of mature fallow areas, may be compatible with reducing the effects of fragmentation. This supports the variable and dynamic interpretation of connectivity, as proposed by Gascon et al. (2004). They see corridors as consisting of biodiversity-friendly land uses that can be integrated with fragments of natural habitat in interconnected networks that help restore functional aspects of the landscape. Where the proportion of mature fallows is high, they may also be seen as a way of enlarging patches of mature forest, which is considered to be even more effective in increasing population size than the establishment of biological corridors (Falcy and Estades, 2007). Other forms of land use may have different roles to play. Scattered

trees in fields and living fences may provide islands and corridors of suitable habitat between forested areas that facilitate movement of animals, seeds and pollen.

Conclusions: Consideration of global conservation priorities

As explained In Chapter 1, this study analysed priorities for conservation from a global perspective, on the basis of the relative geographical extent of the native ranges of the species in question. The analysis is also limited to tree and shrub biodiversity. The degree to which these conclusions hold for other groups of plants and for animals remains untested, although Gillespie and Walter (2001) provide evidence for species richness correlations between birds and woody vegetation elsewhere in Central American seasonally dry tropical forest. Acknowledging these caveats, the principal conclusions of the study in relation to conservation priorities in the MTDF are as follows:

- There is great variability between the study areas, and between sites within each study area, in their species composition and their global conservation importance. Broad-brush approaches to the conservation and management of tree species diversity, which do not account for these differences, should therefore be treated with caution.
- Mature forests, such as those that are found in coastal dry forest areas of Oaxaca in southern Mexico, appear to be particularly important for the conservation of tree species of high global priority. Strategies for the management and use of such areas should pay particular attention to promoting the conservation of these species.
- Many of the non-forest land-uses adjacent to these high priority mature forests, such as long-term fallows, also contain large numbers of high priority species. Protected areas containing high priority mature forests are typically small in size (compared to protected areas in many other parts of the tropics) and vulnerable. Particular attention should therefore also be paid to conserving species diversity outside of these areas in various land uses, both because such land uses may have high conservation priority in their own right and because of their importance in increasing the effective size of the mature forest reserves, which they abut.
- In comparison with the forested areas of southern Mexico, the dry forest agroecosystem, which dominates southern Honduras, contains few tree species of high global conservation priority. There is therefore more room for flexibility in the development of strategies for the management and use of tree species diversity because of the lesser risk of negative impacts on high priority species.

The conclusions presented here with regard to the Oaxaca study area may be broadly applicable to other areas of western and southern Mexico where similar conditions of land use and forest cover exist. Likewise, the southern Honduras study area may be broadly representative of areas on the Pacific slopes of neighbouring El Salvador and Nicaragua where a similar dry forest agroecosystem exists. Nevertheless, any recommendations from this study should not be applied more widely without locally specific verification.

One of the features of this study is the relatively high intensity of sampling carried out in the two study areas. Other surveys have attempted to draw conclusions for regional priorities in Mesoamerican dry forest by using much less intensive surveys. Given that we recognise that not all species in our two regions will have been encountered in our surveys, less intensive surveys are likely to omit even more species. There is, therefore, a very real danger that lower intensity surveys could lead to incorrect conclusions about conservation priorities (see Gordon and Newton, 2006b). The implication of this for conservation organisations is that using species surveys to determine conservation priorities, whilst highly desirable, requires a substantial level of funding if the results are to be reliable, especially when carried out over large areas.

Our methodology uses global range sizes to determine priorities amongst species. If consideration was limited to the range size *within a country* of each species, a type of national prioritisation would be possible. This may, however, result in scarce conservation funding being directed to species that are threatened within a country but common outside it. At local level, in the absence of information about the global conservation value of species, one approach to determining conservation priorities may be to consider trends in the relative supply and demand of the species.

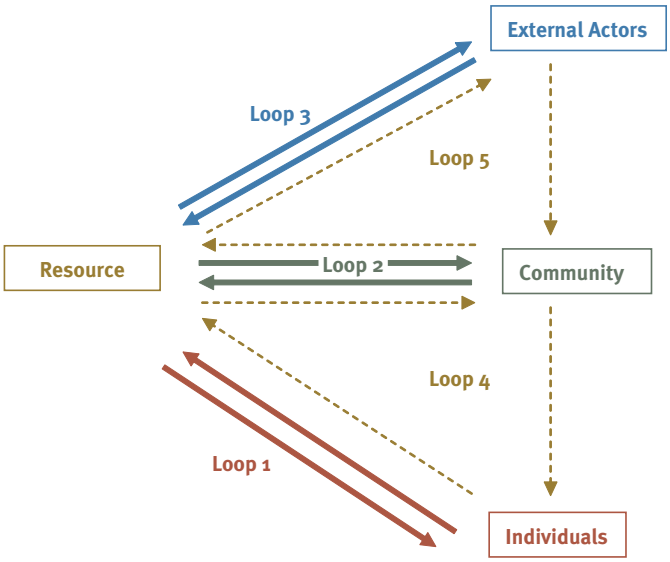
7. Assessing the potential of CTU in the MTDF

This chapter reviews the different forms that Conservation Through Use (CTU) can take, with examples from the study areas. It then examines our third research question relating to the circumstances under which CTU is an effective strategy for conservation of species and ecosystems, and considers how CTU can contribute to improving livelihoods.

Forms of CTU

In Chapter 1, CTU was defined as the 'conservation of any resource, motivated by perceptions of its utility'. The results of the studies carried out in southern Honduras and Oaxaca, presented in Chapters 4 and 5, show that CTU in the MTDF is occurring in a number of ways. In its simplest form, it is a loop: a resource provides a benefit to a user, who in turn conserves the resource. However, a number of different actors may be involved and benefits may reach the conservers directly or mediated by other actors, leading to the existence of a number of potential loops (Fig. 7.1).

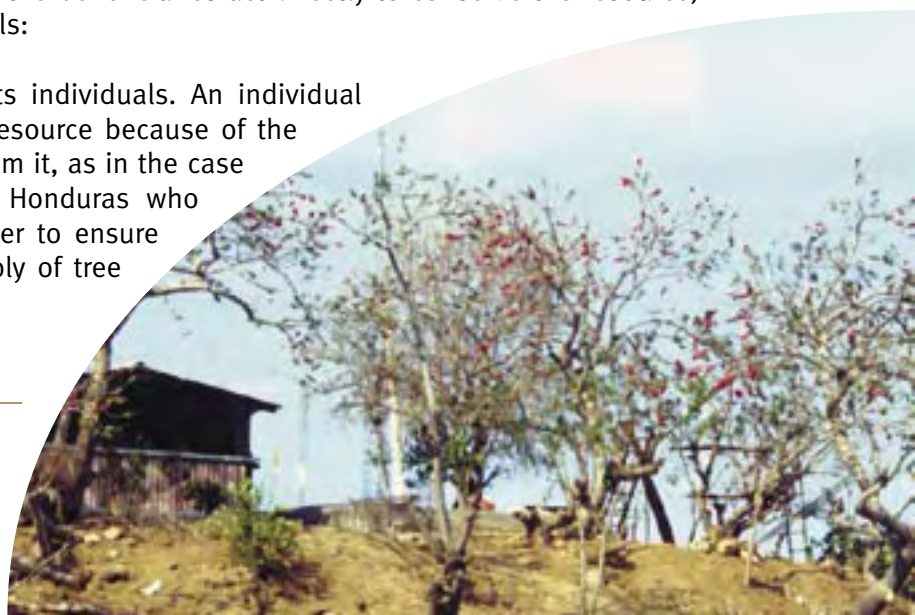
Figure 7.1 Alternative mechanisms of CTU



Direct CTU (loops 1-3)

Direct forms of CTU, whereby the beneficiaries act directly to conserve the resource, may occur at a number of levels:

Loop 1: Conservation benefits individuals. An individual is motivated to conserve a resource because of the benefits he or she derives from it, as in the case of the farmers in southern Honduras who protect trees in fields in order to ensure the maintenance of the supply of tree products (see Chapter 4).



Native dry forest trees (*Spondias purpurea*) that are widely cultivated for their fruit, southern Honduras

Loop 2: Conservation benefits communities. The community as a whole enjoys benefits from the resource, and as a result decides collectively to conserve it. This situation is found in some Mexican communities such as La Jabalina, El Limón and Petatengo. In all these cases the forest is a resource used by the community as a whole for the extraction of products essential for their livelihoods. In La Jabalina an added incentive is the potential of the forest to generate revenue for the community from ecotourism (see Chapter 5). While few if any management projects for timber have been developed in MTDF, the many community forest enterprises existing in other forest types in Mexico (Bray et al., 2005), particularly those in which timber is certified as sustainably managed, are further examples of this kind of CTU.

Loop 3: Conservation benefits external actors. The external actors may include, for example, downstream populations interested in the maintenance of watershed function, or international agencies interested in biodiversity conservation. In some cases, such as protected areas, these actors may be involved directly in the management of the resource. In La Jabalina, Oaxaca, for example, the Huatulco National Park was established by the Federal Government to protect globally important biodiversity (see Box 5.2).

Indirect CTU (loops 4 and 5)

Indirect CTU occurs when the beneficiaries act through others to ensure conservation of the resource.

Loop 4: Benefits to communities result in conservation by individuals. The community as a whole brings about conservation by influencing the actions of its individual members. This can be achieved either through the provision of incentives in the form of distributed benefits and/or through coercion in the form of community regulation. In La Jabalina, El Limón and Petatengo, Oaxaca, Loops 2 and 4 both apply (see Chapter 5): the decision to conserve forest resources for the good of the community as a whole has led both to communal actions, such as the fencing and signposting of communal forests (Loop 2) and individual actions such as the avoidance of felling and burning because of the threat of sanction and the perception of individual benefits (Loop 4).

Community members are conserving coastal dry forest near Huatulco beach in the hope that they will be paid for its hydrological services by a new hotel complex

Loop 5: Benefits to external actors lead to conservation by local actors. Increasingly, local actors are being involved in conservation even when the values protected are principally of interest to external actors. Again, the two options of incentives and coercion apply: external agencies either pay local actors (communities or individuals) to conserve for them the resource that they value, or promote regulations to prevent local actors degrading the resource, if the incentive is not sufficient. This is the case in Petatengo, Oaxaca, where the prospect of payment for the hydrological services

provided to the Bahías de Huatulco hotel complex is one of the factors motivating forest and watershed conservation by community members (see Box 5.1).

In the ideal situation – from the point of view of external actors interested in the conservation of a resource – a resource is of sufficient value to local actors to motivate them to conserve it in the long term, incidentally conserving global values at the same time. Here, loops 1 or 2 and loop 3 apply at the same time, without the need for incentives or coercion.

Can CTU be relied upon for the conservation of rare tree species?

Species level CTU

Very few species of high conservation priority are actively used or individually protected through CTU

CTU at the species level refers to situations where actions are taken to protect populations of particular species because of their perceived utility. In Chapter 6, it was shown that 78 of the species found in the two study areas are of significant global conservation priority. However only three of these species (3.8%) were reported by farmers as being actively used (Table 7.1) and only one of these (*B. quinata*) was reported as being actively protected at a species level.

Table 7.1 Species of high global conservation priority that were also reported as being used

Species	Status and location	Use
Brongnartia bracteolata	Category B (Oaxaca)	Reported by five interviewees (6%) as used for timber
Bucida macrostachya	Category C (Oaxaca)	Reported by only one interviewee as used for timber
Bombacopsis quinata	IUCN vulnerable (Honduras)	Among the 10 species most reported as used for timber in the Honduras study communities (see Table 4.1).

Even in the case of *B. quinata*, the one high priority, actively used and actively protected species found, CTU is infrequent. Only 2 people out of the 79 interviewed in southern Honduras reported actively protecting it in their fields, as compared to 30 in the case of *Cordia alliodora* (see Table 4.7). In the community of Los Coyotes, as *B. quinata* has become progressively scarcer, instead of conserving it farmers have switched to using other species, such as *C. alliodora*, whose timber is a suitable if not perfect substitute for *B. quinata*. Farmers' failure effectively to conserve *B. quinata,* despite its value to them, may be explained by this species' limited ability to regenerate and compete in agricultural fields, in comparison with, for example, *C. alliodora* or *Swietenia humilis* (Box 6.1). As a result, it is more commonly found in small woodland areas, for example along streams, than in farmers' fields. These small woodland areas tend to be of open access and subject to illegal tree felling, with the result that the conservation status of *B. quinata* is far from secure.

The evidence presented in the preceding chapters indicates that species level CTU contributes little to the conservation of species of high global conservation priority, at least in the two study areas. However, the example of *L. salvadorensis* suggests that it would be a mistake to rule out completely the potential of species level CTU for global conservation. The patchy nature of the natural distribution of this species means that, by chance, it was not found in any of the communities included in this study. *L. salvadorensis* is a Category B species (of second highest conservation priority in terms of global rarity), which is thought only to occur on the Pacific drainage of eastern El Salvador, southern Honduras and western Nicaragua (Hughes, 1998). Where it does occur, however, it is highly valued by farmers as a source of durable posts and is frequently protected in fields (Hellin and Hughes, 1993) where, in contrast to *B. quinata*, it regenerates and competes well. Although no reliable information is available on trends over time in the population numbers of *L. salvadorensis,* it is probable that this active protection in fields contributes significantly to the numbers of individuals in the landscape that are able to reach reproductive age.

The practice of protecting useful trees in fields (a form of CTU) is relatively common in southern Honduras, where off-farm sources of tree products are hard to come by because of reduced areas of forest and fallow. By contrast, the practice is almost unknown in the communities studied in Oaxaca, most of which still contain significant areas of forest and fallow from which the population can obtain tree products. This difference suggests that the practice of species level CTU in fields is directly motivated by the threat of scarcity of off-farm tree products and that, conversely, off-farm product abundance is a disincentive to on-farm tree conservation. From the conservation perspective, this implies that species level CTU in fields constitutes a 'last-ditch' solution, which may only come into play when, as in the case of southern Honduras, much of the off-farm resource and most, if not all, of the species of high conservation concern that may have existed in it have been lost.

However, the case of El Sanjón, in Oaxaca, shows that even when off-farm trees and forests have largely disappeared, species level CTU in farmers' fields does not necessarily occur and therefore cannot be relied on for the conservation of species of high conservation priority. As we have seen, farmers in the flat lands of El Sanjón rarely protect trees in fields for two reasons: firstly, they have relatively good access to sources of income, which enables them to purchase fuel and building materials rather than relying on collecting them from on-farm trees; and secondly, the suitability of their lands for lemon production means that any trees retained on farm would have a significant opportunity cost in terms of the lost space for lemon trees. A suggestion by Mendez et al. (2007) is that certain types of certification could provide new incentives for species level CTU. Coffee farmers in El Salvador, for example, seem to show an interest in maintaining tree species of conservation concern in their plantations because this may allow them to obtain shade certifications, that can result in price premiums for their coffee; and also because these trees are attractive to ecotourists (Mendez et al., 2007).

The above examples suggest that species level CTU can only contribute to the conservation of tree species diversity in the case of species with a very specific set of characteristics:

Characteristics of species that could benefit from species level CTU:

- Of high conservation priority;
- Of sufficient value to farmers to motivate them to invest in protection, even if this involves negative impacts on crops or other costs;
- With uses which lend themselves to sustainable management (such as fruit, which does not entail felling of the tree, or timber if the species is prolific or vigorous enough to allow extraction to be compensated for by regeneration);
- With uses which cannot easily be provided by substitute species;
- With the ability to regenerate and compete in highly disturbed agricultural environments (particularly for timber trees, which farmers tend to maintain in their fields rather than the more protected homegarden environment).

In addition, species level CTU is more likely to be successful if the following socioeconomic and environmental conditions apply:

Conditions under which CTU may contribute to conservation at the species level:

- Secure individual long-term rights to tree use;
- High levels of demand or need, either for subsistence use or for sale, for the goods and services produced by the tree (in the case of sale, this implies easy market access);
- Scarcity of the products and services provided by the species in question;
- Low levels of opportunity cost associated with tree management, e.g. when combined with low value crops or shade resistant crops;
- Awareness on the part of farmers of the silvicultural potential and yield of the species involved;
- A favourable regulatory context, which minimises the restrictions and administrative difficulties associated with marketing tree products (this may require the decentralisation of controls and the strengthening of social auditing, in order to avoid abuses);
- A biophysical environment which is favourable to tree regeneration; this may, for example, largely rule out many flat lands where mechanised cultivation is used.

The case of *B. quinata* underlines the need for all of the above conditions to be met simultaneously; the existence of market demand for a species is not enough to guarantee its conservation and may, in fact, have the opposite effect if the species in question does not regenerate easily.

Ecosystem level CTU

CTU at the ecosystem level refers to situations where actions are taken to protect an ecosystem (e.g. a forest) as a whole, because of perceptions of its utility and value, for example as a source of useful species or of environmental services. Several of the examples in Oaxaca, reported in Chapter 5, suggest that CTU has potential at an ecosystem level. Forest conservation by communities in Santa María Huatulco, (including the establishment of communal reserves and the application of restrictions on the clearance of high forest and on the use of fire for agricultural site preparation) has been motivated by both its perceived role in protecting water supplies and its potential for revenue generation, through ecotourism and the sale of environmental services. Were it not for these measures, it is probable that

significant areas of forest would have been cleared, either permanently or temporarily, for agriculture and cattle ranching, as the rural population grew. Ecosystem level CTU in this case is of both local and global significance: as well as being highly valued and therefore protected by local communities, the forests affected contain large numbers of species of high global conservation priority.

Our research suggests that a specific set of conditions must simultaneously be met for ecosystem level CTU to work:

Conditions under which CTU may contribute to conservation at the ecosystem level:

- The goods and services produced by the ecosystem confer greater benefits on those who are responsible for its management than alternative land uses. This implies the existence of a need or demand for the goods and services and, where the benefits are financial, functioning markets;
- The ecosystem has the long-term capacity to produce the goods and services which motivate investments in its conservation;
- The goods and services produced by the ecosystem are compatible with the long-term conservation of its individual components (e.g. species) of high conservation priority;
- Effective structures exist for formulating and enforcing regulations, based on awareness of the condition and potential of the resource in question.

The above conditions are met in the cases of parts of La Jabalina and, to a large extent, Petatengo. They are not met in El Sanjón, where forest conservation cannot compete with lemon production, or in some situations in El Limón, where the effectiveness of community regulation in the enclosures of individual *ejido* members is limited.

As long as they are not adversely affected by the use given to the ecosystem, the particular characteristics of high conservation priority species are less critical with CTU at ecosystem level than at species level. Indeed, most of the high priority species currently conserved in Oaxacan forests are incidental 'free riders' which are not valued individually but benefit from the perceived value, and the resulting conservation, of the forest as a whole.

Indications on the potential of ecosystem-level CTU, from the dry forest communities of coastal Oaxaca included in this study, cannot necessarily be generalised widely to national level or to other forest types, particularly when forest use is based on the commercial extraction of timber. A study of 450 Mexican *ejidos*, for example, found that communities practising commercial forestry had difficulties preventing encroachment, especially by non-members of the *ejidos* (Alix-Garcia et al., 2005). Nevertheless, based on a comparison of land use change in Mexico's protected areas and 22 *ejidos* in Guerrero and Quintana Roo, Durán-Medina et al. (2005) consider well-organised *ejidos* that have developed a community-based forestry plan to be among the conservation scenarios with the greatest long-term potential. More generally, Hayes (2006) presents evidence from thirteen countries around the world for the effectiveness of forest conservation when governed by 'users who establish and recognise forest rules'.

Can CTU contribute to improving livelihoods?

In all of the cases of CTU presented here, the driving force has been the desire of local communities or individual farmers to promote their livelihoods, by ensuring the continued supply of subsistence products or environmental services, or through generating income. However the degree to which CTU succeeds in meeting these objectives consistently and in the long term, varies a great deal.

Tree level CTU and livelihoods

The fact that most of the informants in the study communities in Honduras reported that they enjoy adequate access to tree products (see Tables 5.3 and 5.4), despite the limited areas of forest and fallow remaining there, suggests that CTU, in the form of the protection of trees in fields, has to date been largely effective with respect to this aspect of farmers' livelihoods. Farmers have responded to the decreasing availability of tree products in fallows and forests by protecting trees such as *C. alliodora* within their fields as a source of products. Under favourable conditions, such as the good access to markets for tree products enjoyed by the population of Los Coyotes, the protection of trees in fields can be highly profitable compared to agricultural income.

A. adstringens with signs of bark harvesting, Oaxaca

Two of the cases examined in the case study chapters, however, demonstrate that farmers' preference for a tree resource does not always lead to successful CTU. Thus, the limited ability of *B. quinata* to regenerate and compete in agricultural environments has resulted in farmers in Los Coyotes, Honduras, having decreased access to this species and being obliged to use other species of inferior quality. In El Limón, Oaxaca, the limited effectiveness of community-based controls over farmers' management of resources within their individual plots has led to the over-exploitation of *A. adstringens* bark. It remains to be seen whether *A. adstringens* will continue to decline locally or whether, given the existing conditions of individual tenure and secure use rights, and the ready coppicing ability of this species, farmers will be motivated to take active measures to protect the resource once a certain level of scarcity is reached.

Conditions under which tree level CTU may contribute to livelihoods:

- Large numbers of individuals (including seeds, seedlings and stumps) of species which yield useful products and services, can regenerate easily in fields and tolerate pruning and other management activities;
- Access to markets (either within or outside the community) for the tree products;
- Secure individual long-term rights to tree use;
- A favourable regulatory context for sustainable exploitation;

- An environment which is favourable to tree regeneration (for example without excessive intensity of burning or soil compaction).

Although the CTU of certain tree species may contribute to farmers' livelihoods, the range of species found in farmers' fields and fallows, and the relative proportions of each, tend to vary widely from place to place in the MTDF. Before assuming that CTU can be depended on to contribute to livelihoods in any given site, it is necessary first to carry out field assessments of the types of species present and the numbers of each. Such assessments should examine not only fully developed trees but also live stumps and seedlings, which can make up the vast majority of the individuals present in the agroecosystem (see Box 4.2).

Ecosystem level CTU and livelihoods

The effectiveness of ecosystem level CTU in contributing to farmers' livelihoods also varies from place to place, as shown by the contrasts between the study communities in Oaxaca. In Santa María Huatulco, community-based control is apparently effective in ensuring the survival of communal forests from which community members obtain their water supply, even though anticipated income from ecotourism and the payment for environmental services has yet to be fully realised.

Meanwhile in Petatengo (also in Oaxaca), efforts by a local NGO to promote sustainable forest management and timber harvesting, as a source of income and to increase community members' valuation and therefore conservation of communal forests, has encountered some resistance among certain sectors of the community (see Box 5.1). Like Santa María Huatulco, Petatengo also has strong community-based control structures. An important difference between the two, however, is that in Santa Marìa Huatulco the proposed income-generating activities are non-extractive whereas those in Petatengo are extractive and, therefore, have the potential to affect the condition of the communal resource. The Petatengo case suggests that, on communal lands, commercially-oriented extractive uses can generate conflicts about how individual benefits may affect the interests of the community as a whole which need to be addressed with particular care.

Conditions under which ecosystem level CTU may contribute to livelihoods:

- Physical characteristics of the ecosystem, which enable it to contribute to livelihoods through the provision of goods and services;
- Appreciation by the people who manage the ecosystem of its provision of, or potential to provide, products and services;
- Compatibility of the enjoyment of the products and services with the long-term conservation of the resource;
- Effective mechanisms for the distribution of the benefits and/or the compensation of the costs of conservation to those who invest in it;
- Effective mechanisms for the participation of those who receive products and services from the resource in decisions relating to its management;
- Effective regulation of the management and use of the resource.

Conclusions

To summarise, the case studies have demonstrated a number of different forms of CTU in action. They can be distinguished in terms of whether the person or people benefiting from the conservation are directly or indirectly responsible for implementing conservation activities, whether CTU is ensured through regulation and/or incentives, and by whether species or ecosystems are the object of conservation.

From the point of view of the conservationist interested in globally important tree and shrub diversity, species level CTU is currently not of great significance as very few tree and shrub species of conservation concern are of sufficient interest to farmers to warrant active protection. CTU at ecosystem level appears to have more potential, at least in areas with large numbers of high conservation priority species, because it leads to the conservation of the forest ecosystem as a whole (in our examples) and thereby of the priority species within it, irrespective of their individual importance to local people.

From the point of view of local populations keen on improving their livelihoods, the success of both species and ecosystem level CTU depends on a number of factors including secure tenure and access to markets for the products (or services) of the species or forests concerned. While decisions about species level CTU can be taken by individual farmers, ecosystem level CTU may be more complicated because it more commonly involves decision-making and benefit-sharing at community level.

In the next and final chapter we discuss the circumstances under which CTU is particularly appropriate and make specific recommendations for the study areas.

8. Recommendations for implementing CTU in Mesoamerican tropical dry forest

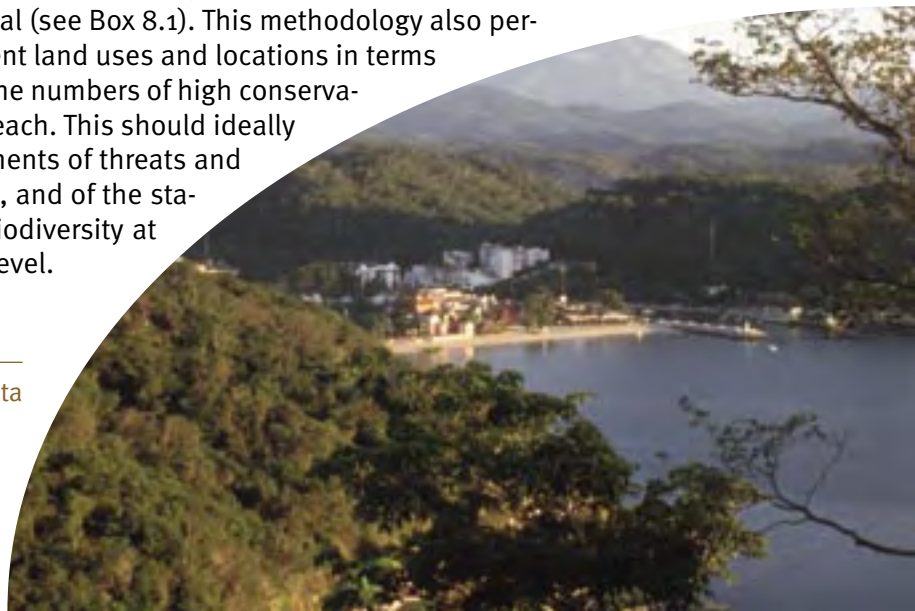
The previous chapters have shown that conservation through use can be effective if certain conditions are met. In this chapter we set out the steps which decision makers in the Mesoamerican tropical dry forest need to take in order to determine when they can rely on CTU to meet their objectives; and how to help sustain or create the conditions for it to work. We then set out priorities for action specific to the two study areas.

When to promote CTU

There are many alternative approaches to conservation, both competing and complementary. It is therefore increasingly important for governments and conservation NGOs to assign the limited resources available in a rational manner. As we have seen in the preceding chapters, CTU may already be conserving species and ecosystems in some areas. In an ideal world, CTU would be self-sustaining, as the benefits from conservation motivate further conservation (see Chapter 1). However, the relationships between local farmers or communities and their natural resources are highly variable and dynamic. Below we outline very briefly some of the steps necessary to determine whether and where CTU has a role.[14] While our focus in this book has been on global conservation priorities, similar steps are also useful for deciding on conservation initiatives at a more local level.

(i) Determine which species, types of vegetation or specific areas of vegetation are of greatest global conservation concern: is there a global justification for investing in CTU?

As a starting point, important sources of information include the IUCN Red List of endangered species (http://www.redlist.org/) and the WWF Global 200 list of the world's most biologically outstanding habitats (Olson et al., 2001). These can be supplemented by local checklists such as the one provided in Appendix 4. A relatively rapid and low cost methodology for comparing the conservation priorities of large numbers of other species is presented in Chapter 3 and Appendix 1. To achieve this, collaboration between local NGOs and herbaria is likely to be essential (see Box 8.1). This methodology also permits the comparison of different land uses and locations in terms of their bioquality, based on the numbers of high conservation priority species found in each. This should ideally be complemented by assessments of threats and trends in population numbers, and of the status of other components of biodiversity at both species and ecosystem level.



Beach resort in dry forest, Santa Cruz Huatulco, Mexico

14. See also suggestions for further reading in Appendix 6

For each species or habitat of conservation concern, conservation priorities need to be made explicit (e.g. increasing the numbers of a particular species or improving its age structure or conserving a particular ecosystem) so that specific management objectives can be formulated (Hamilton and Hamilton, 2006).

Box 8.1 Improving links between NGOs and herbaria

For conservation oriented NGOs working in the field, it is vitally important to know which species are present in their locality, and which of these are priorities for conservation. However, tropical floras in developing countries are typically poorly known and resources to fund botanists often limited. The few botanists capable of helping NGOs are usually concentrated in city-based herbaria. NGOs can encourage such institutions to be more responsive to their needs by:

- *Collecting existing botanical information for the region*. Despite a lack of information on local species, much can be found in published literature about the importance of vegetation types in a region of interest, and of the importance of the floras of similar forest types from published checklists. With this kind of information, a herbarium-based botanist is more likely to be interested in forging links with an NGO.
- *Budgeting for plant identification services*. Plant identification is a skill that may have to be paid for. NGOs cannot assume that such services can be supplied without cost. Funding proposals need to budget for such services. Rapid botanical surveys may take a relatively short amount of time in the field, but *at least* an equal amount of time should be expected for species identification in the herbarium.
- *Training staff in basic collection techniques*. With relatively little training, locally based staff can become 'parataxonomists' and take on much of the fieldwork. The key to this is to understand basic collecting techniques. With good botanical collections, pressed, dried and sent, along with field notes, to the herbarium, the botanist can dedicate his or her relatively expensive time to specimen identification alone. It may therefore only require one brief field visit for the botanist to train local staff.
- *Demonstrating a long-term commitment to conservation*. A herbarium is more likely to be interested in collaborating with an NGO if that NGO can demonstrate a long-term commitment to local conservation in its planning processes.

Good botanical specimens facilitate identification in the herbarium

(ii) Determine what value the species or ecosystem has for local people: is there a 'use' on which to base CTU?

This is likely to vary between different forest types, socioeconomic groups, forms of resource users and ethnic groups. If no previous studies exist in the area, a number of methodologies are available for collecting the information required, including questionnaires, semi-

structured interviews and participatory rural appraisal (PRA) tools such as species ranking matrices (Pretty et al., 1995; Geilfus, 2000). The choice of the methodologies applied may depend on the balance required between quantitative and qualitative information, and the size of the human population to be covered.

Where individual species have no evident 'use' value, they may nevertheless be conserved within a land use or forest ecosystem that people are conserving for some other reason (essentially as 'free riders').

(iii) Determine whether the benefits that local people receive from trees and forests are under threat: is there a local motivation for CTU?

Local people are only likely to carry out CTU if they recognise that the trees and forests which provide them with benefits are under threat, and that they have no other means of obtaining the benefits than conserving the particular trees and forests in question. It is therefore important to determine, in conjunction with local people, whether forest cover, the frequency of individual species and the availability of tree products are changing over time; how the use of the species/ecosystem fits into farmers' livelihoods; and whether the species which people currently depend on are unique in their usefulness, or could easily be substituted by other species (thereby avoiding the inconvenience and opportunity cost which might be implied by taking conservation measures, such as accepting shade on their crops, or 'setting-aside' areas of communal forest). This type of information can normally only be obtained by participatory socioeconomic research at farm and community levels, involving as appropriate semi-structured interviews and PRA tools such as time lines or ranking matrices. Such assessments need to include a gender element as changes in availability and quality may have different implications for men and women.

Women in Agua Zarca, southern Honduras, still make soap from the seeds of *aceituno* (*Simarouba glauca*) but easy access to purchased soaps means there is little motivation to conserve this species in other communities

(iv) Determine the social and institutional context for resource management: what are the factors that affect farmers' decisions on how to manage the resource?

As we have seen, CTU at species level is frequently determined by the decisions taken by individual farmers, whereas ecosystem-level CTU is more likely to depend on decision-making at community level. To understand how farmers and communities take these decisions, as the basis for the development of CTU strategies, necessary information may include the nature of tenure and usufruct rights (e.g. formal rights backed up by titles versus informal but locally recognised rights), the main components of local land use and agricultural production systems (including markets), and the extent to which individual decision-making is constrained by community-level decisions (for example through cultural norms or formal regulations). In the

case of communal resources, it is also important to understand the nature of the mechanisms for sharing costs and benefits between community members, and local enforcement of rules. Useful tools for gathering such location-specific information on natural resource decision-making by farmers and communities include focus groups and semi-structured interviews as well as field visits with farmers and other resource users.

(v) Characterise the factors that determine sustainability of CTU: is it likely to be sustainable in the long term?

Smallholder farming systems in the MTDF are typically highly complex and dynamic. In order to define strategies for CTU which are likely to be sustainable in ecological, socio-economic and political terms, it is necessary to understand the pressures acting on farming and livelihood systems, the ways in which they respond to these pressures (which in turn will depend on the inherent characteristics of the resource and its stakeholders) and trends over time in these pressures and responses (Barrance et al., 2006).

The long-term ecological sustainability of use is likely to depend on the nature of the use itself (for example does it imply killing the tree or otherwise reducing its ability to compete or reproduce?), its magnitude (how does the rate of removal of individuals compare with the rate of regeneration?) and the nature of the resource affected (is it abundant, does it reproduce or resprout easily, does it tolerate disturbed conditions?). Much of this information may be provided by simple field observations, together, where possible, with comparative timeline analyses carried out with local people looking at how historical trends in levels of use have related to trends in abundance of the species in question. This may be complemented, where necessary and possible, by quantitative field inventory of population numbers and size classes, preferably carried out in a participatory manner in order to equip local people with the tools and capacities to define and monitor acceptable use levels.

Socio-economic factors relate to population movements, changes in agricultural production systems and other livelihood opportunities, and market trends for the products of 'useful' species or ecosystems and any substitutes. Broad-brush information, e.g. on population size and trends in the production of specific crops and in farm size, can be found in population and agricultural censuses. PRA tools such as timelines may be useful to provide more locally specific indications of the timing and general directions of trends. Aerial photographs can provide very useful and locally specific indications of trends but quantification of trends in parameters such as field sizes is laborious, and it is sometimes difficult to obtain photographs over the required time period. Satellite imagery can also be very useful, for example in showing trends in vegetation cover and condition. Market surveys are needed to determine trends in prices and volumes of traded products.

Political factors broadly include land tenure, access regimes and enforcement. Information on regulations and policies, which affect how farmers and other resource users manage trees and forests and which may favour or hinder CTU, can be collected relatively easily through a review of laws and policy documents. However it is also important to assess how such instruments are interpreted and applied locally, as this may differ greatly from what was

originally intended. Such information can be gathered through local focus group meetings and semi-structured interviews.

How to promote CTU

It is important to realise that recognition and support of existing CTU may be as important as promotion of new CTU initiatives. To define appropriate support and promotion activities, it is first necessary to determine the scale at which action will be taken. Depending on the type of CTU being promoted, the focus of action might be individual farmers, communities or a combination of the two. Particularly in the case of mosaic agroecosystems in which species of high conservation value are found in both mature forest fragments and forest fallows, landscape or ecosystem approaches (Sayer and Maginnis, 2005) might be most appropriate, possibly involving interaction with various administrative layers. Secondly, it is important to be aware of the balance of costs and benefits arising from CTU. Understanding who bears the costs of CTU and who receives direct or indirect benefits (see Fig 7.1) will determine whether it should be accompanied by measures to improve the equity of benefit distribution or to compensate for possible negative impacts on the interests of any stakeholder group.

Taking into account scale and cost/benefits as well as the findings of the assessments set out in the previous section, promotion activities fall into three main groups:

(i) Regulations

Regulation and control are a necessary, though not sufficient, condition for sustainable use (Hutton and Leader-Williams, 2003). Gibson et al. (2005) argue that enforcement by local user groups of rules on extraction is the most important condition for ensuring effective resource management as it counteracts the temptation for individuals to 'defect' or take more than is allowed. In the broadest sense, this includes some or all the following:

- *Promoting tenure and usufruct rights.* Influence may be brought to bear on the formulation of local, national and international laws, regulations and conventions, in order that local people can feel unambiguously secure that they will be assured of use benefits as a result of any resource conservation activities they carry out.
- *Developing awareness and strengthening community organisation.* The non-use value of forests to local people is often a product of traditional knowledge and environmental customs. This may be enhanced by community development activities (including participatory research, documentation of customary knowledge and environmental education), and the promotion of a supportive legal framework. It is also important to support the decision-making and regulatory structures required to ensure that individuals' actions are in the community's best interests.
- *Promote benefit distribution mechanisms.* In order to ensure that those who determine how the resource is managed feel motivated to participate in its conservation, transparent and efficient mechanisms are required for the equitable and effective distribution of benefits. In reality, certain groups of resource users can influence how others use and benefit from the resource through regulation (see Loop 4 in Figure 7.1). An example is that of *ejido* members in Mexican communities who, because they value

the resource, regulate its use by non-*ejido* members. From the conservation viewpoint, it is not necessary for members and non-members to receive the same benefits. However, for CTU to be socially sustainable, it is desirable for all resource users to participate in some way in resource management decisions, and to receive a corresponding share of the benefits.

- *Streamlining regulations.* Increasing the regulatory burden (through new rules or better enforcement of existing ones) on poor farmers may have the perverse impact of marginalising them into illegality (Schreckenberg and Bird, 2006). It may instead be more effective to reduce the time and costs of obtaining timber felling and transport permits to increase the attraction to farmers of managing certain timber species, as long as sufficient regulations and other controls are still maintained to prevent abuse. With respect to community-based forest management, Menzies (2007) argues that it is counterproductive to impose regulatory frameworks constraining the role of community institutions to the extent that the perceived extra burden of forest management outweighs the benefits to the community, undermining the incentive to care for the resource as a valuable community asset.

(ii) Incentives

Positive incentives tend to be more powerful and cost effective than a regulatory system that relies primarily on negative incentives (Murphree, 2003). Examples include:

- *Research and promotion of income generation activities.* Communities may require training and assistance in order to take advantage of certain forms of resource use that lend themselves to CTU, such as ecotourism, the sale of environmental services and NTFP production.
- *Promotion of processing and marketing opportunities.* The value to local people of many species of high global conservation importance is limited by their inability to add value locally to the species' products or to market them competitively. Local processing can be encouraged by the promotion of appropriate local technology and training. This needs to be supplemented by market research into the potential demand for new products or qualities (e.g. the properties of lesser known timbers and how best to introduce them into traditionally conservative markets), provision of marketing skills and the support of marketing infrastructure and information systems.

These forms of 'in kind' incentives, aimed at capacity building, are likely to have more sustainable impacts in the long term than financial or material incentives which in the past have been used by many development and conservation projects in order to influence farmers' behaviour.

(iii) Monitoring effectiveness

As was suggested in Box 1.1, there is a risk that some forms of CTU may prove unsustainable, leading to a progressive decline in the resource affected. It is therefore important that the promotion of CTU is accompanied by adequate provisions for monitoring the effectiveness of the strategies applied and agreed mechanisms to amend them as necessary. Factors to be monitored may relate to the species being conserved, such as total population numbers and

population structures (e.g. relative proportions of different age classes), or to the ecosystem concerned, such as the area covered and its composition in terms of species and size classes. It may also be important to monitor socio-economic factors such as how the activity is affecting the interests of different stakeholders, relative to the benefits they receive.

Priorities for action in the case study areas and similar sites

General priorities for conservation in the MTDF

In order to maximise the impact of the resources available globally for conservation, initiatives aimed at conserving MTDF tree species diversity should focus primarily on mature forest patches of high bioquality such as those of coastal Oaxaca (see Chapter 6), rather than agroecosystems of relatively low bioquality such as those of southern Honduras. Actions focused in this way on specific sites with high bioquality are likely to offer better value for money in global terms than transnational biological corridors, which encompass large areas of low bioquality.

It is probable, but should not be assumed, that much of the rest of the highly disturbed agroecosystem of the Pacific slope of Central America has similarly low bioquality to southern Honduras, in terms of tree species, and that investments there would have similarly limited impacts on the conservation status of globally rare species, compared with areas of proven high bioquality such as coastal Oaxaca. Whilst we speculate that the differences between bioquality between southern Honduras and Oaxaca are at least partially a result of greater disturbance and conversion in the former, this does not mean that all highly disturbed dry forests in Mesoamerica have low bioquality. The only reliable way to determine variation in bioquality is by comparative sampling, as we carried out here.

Although the great majority of the globally important tree species in the MTDF are found in high bioquality areas such as those in coastal Oaxaca, a few (such as *Bombacopsis quinata* and *Leucaena salvadorensis*) are found only in low bioquality agroecosystems. While *L. salvadorensis* appears to survive reasonably well under these conditions, specific conservation strategies are needed for the very few globally rare species (such as *B. quinata*) which are not well represented in conservable mature forest fragments and do not prosper in agroecosystems. As a last resort, complementary *ex situ* conservation measures may be considered for these species.

Priorities in the southern Honduras case study area

Actions related to promoting CTU in the dry zone of southern Honduras should focus principally on its potential contribution to livelihood support, because of the high levels of poverty, the limited livelihood support options open to its population and their heavy dependence on tree products, combined with the low bioquality of this area. At the same time, it is important to promote the conservation of the few species of high global priority that exist there, such as *L. salvadorensis*, for example through promoting awareness of their conservation status and management options among local conservation and development organisations.

The following specific actions could be taken, in order to realise the potential of CTU to contribute to rural livelihoods in the area:

1. Streamlining of regulations and procedures governing the harvesting and marketing of trees which regenerate naturally in agroecosystems, in order to make it more attractive for farmers to manage trees as an easily-saleable cash crop.
2. Promotion of local (municipal and community) level control over the harvesting and marketing of trees which regenerate naturally in agroecosystems, accompanied by provisions for local social auditing.
3. Participatory activities to assist farmers to appreciate the potential of CTU to contribute to their livelihoods, and the potential compatibility of naturally regenerated trees in fields with agricultural practices.
4. Promotion of markets and local processing facilities for timber coming from naturally regenerated trees in agroecosystems (subject to the introduction of effective, streamlined local controls).

These recommendations are likely to be applicable in general terms throughout much of the Central American dry forest agroecosystem, particularly in central and eastern El Salvador, the southern parts of the departments of Intibucá and Lempira in western Honduras, and much of western Nicaragua, as broadly similar conditions of resource scarcity and tree tenure exist throughout this area (indeed, first hand observations indicate that there is evidence of similar species level CTU being carried out in each of these areas). The broad similarity between the four Honduran study communities in terms of the functioning of species-level CTU, despite variations in altitude, rainfall, access and production systems, suggest that these factors have relatively little effect on the replicability of these recommendations.

There is however much variation in local-level conditions. The conclusions presented here with regard to species-level CTU do not necessarily apply to:

- large land holdings whose owners' livelihoods are not significantly affected by the scarcity of tree products;
- areas such as flat lowlands with potential for irrigation, where, it is possible to produce high-value crops, and there is therefore a high opportunity cost associated with tree conservation; or
- areas where the tradition of using fire to clear vegetation or control pests inhibits natural regeneration.

Priorities in the Coastal Oaxaca case study area

In order to conserve tree species of global conservation priority, particular attention should be paid to the conservation of the largely intact forests and mature fallows of coastal Oaxaca, especially those between Huatulco and the western end of the Isthmus of Tehuantepec. High bioquality patches in these areas should be managed as part of the wider agroecosystem in order to increase their effective size and maximise the gene flow between them. This means that conservation approaches must go beyond promoting conservation of isolated forest patches, and work with the intervening landowners, including consideration of incentives

such as Payment for Environmental Services (see Sánchez-Azofeifa, et al., 2005). Priority should also be given to assessing the conservation priority of similar areas elsewhere in southern Mexico.

There is strong potential in coastal Oaxaca for CTU to contribute both to the conservation of globally important tree species diversity and local people's livelihoods through the following specific actions:

- Participatory initiatives to raise awareness among rural communities of the products and services provided by their forests and the options available for conservation through use.
- Participatory initiatives to develop and strengthen community-based structures for decision-making and regulation in relation to tree and forest use.
- Promotion of policies which value and support community-based structures for land management and decision-making, for example in the areas of agricultural incentives, land tenure and regulation.
- Research and promotion of strategies for increasing the biodiversity-friendly income-generating potential of community-based natural resource management, including the identification of efficient production technologies and marketing institutions, and the development of a supportive policy framework.
- Participatory development of mechanisms for the payment for environmental, recreational and other services from forests, and for the effective distribution of the resulting benefits to the people involved in, or affected by, forest conservation.
- Policy and regulatory support to the development of mechanisms for the payment for environmental services.

These recommendations are likely to be replicable wherever areas of vegetation of high global conservation importance persist, and where effective community organisation in favour of resource management and use exists. These conditions, particularly with regard to community-based management, are highly specific to Mexico, because of the particular cultural and legislative context found there (although, as seen in the communities of El Sanjón and El Limón in Oaxaca, there is also variation within Mexico with regard to the effectiveness of community organisation). In particular, similar conditions of extensive areas of apparently intact forest under similar conditions of community-based management may be found in the southern and western Mexico states of Guerrero, Michoacán and Jalisco, to the west of Oaxaca.

Future research priorities in relation to CTU in the MTDF

Case studies such as the ones presented in this book inevitably raise many new questions. Several priority areas for future research were identified:

- The local level work carried out in the course of this study in identifying species of global conservation concern (particularly those most susceptible to the effects of fragmentation and forest conversion) and the sites where they are found, needs to be repeated elsewhere in the region to increase the evidence base for conservation decisions.

- The objective approach presented here for assigning conservation priorities should be applicable to other life forms (with modifications, where necessary, to the methodology and criteria used for assessing priorities) and it would therefore be useful to develop a methodology for prioritising sites on the basis of the combined 'bioquality' indices of the different life forms which they contain.
- Future research could usefully aim to distinguish between cases where conservation is required at the level of whole landscapes, land use systems or vegetation types, and cases where it should focus on the conservation of individual species within the landscape.
- It is important to monitor the implications for the conservation status of dry forest, of changes in laws and policies in Mexico relating to communal tenure and community-based natural resource management.
- The hydrological and carbon storage benefits resulting from non-forest land management systems which allow the survival of large amounts of live tree material (including live stumps) need to be studied, in order to determine appropriate levels and types of support, including possible compensation to farmers for the provision of such benefits.
- Further work is needed with farmers to determine which global conservation priority species are of local value, in order to help identify opportunities for CTU.
- Finally, a more in-depth understanding of the costs and benefits to farmers of different tree and forest management practices could underpin programmes to support the maintenance or introduction of biodiversity-friendly land use amongst farmers.

Concluding remarks

In this book we have shown, based on case studies in MTDF landscapes of Oaxaca and Honduras, that CTU can under certain circumstances be effective for the conservation of globally-rare tree and shrub biodiversity (as in the case of the forests and mature fallows of coastal Oaxaca), and of the natural tree and shrub resources on which local people's livelihoods depend (as in the case of southern Honduras). We conclude the book with a number of caveats, however:

- Care should be taken to avoid assuming that synergies will naturally emerge between rural poverty reduction and the conservation of renewable natural resources, which is the 'win-win' situation hoped for under CTU (Barrett et al., 2005). MTDF landscapes are never static and even currently well conserved areas may come under threat in the future, for example from changing land use practices if *ejido* land is parcelled off or if there are major changes in agricultural commodity prices or demography. Constant monitoring is therefore required to ensure the utility and sustainability of CTU practices, backed up by support where necessary to facilitate adaptation to changing circumstances.
- We must also be aware of the complexity that underlies the seemingly simple term 'win-win'. In reality both rural development and conservation have multiple stakeholders with differing interests. It is most unlikely that all such stakeholders can be out-right winners. A win-win scenario is better envisaged as one in which conservation and rural

development goals are set by broad consensus, and trade-offs may be necessary to achieve them.

- Our research shows that the capacity of many dry forest species (albeit mainly those of lesser conservation concern) to persist in large numbers in highly disturbed agroecosystems, such as those of southern Honduras, should not be underestimated. To do so, and thereby to overstate the level of threat faced by such species, could lead to the misdirection of limited conservation resources toward species that are not under significant threat (Boshier et al., 2004) and the possible imposition of unnecessary restrictions on the productive activities of local people. The Rapid Botanical Survey method used in this study provides a useful and objective tool for identifying where the global priorities for conservation truly lie.
- Decisions on conservation priorities and strategies elsewhere in the MTDF need to be taken on a case-by-case basis, and in an informed and objective manner, based on systematic inventories of the numbers of high conservation species which they contain and investigations into productive, organisational, economic and tenure conditions. Assessments of conservation priorities and the development of conservation strategies should be integrated with socio-economic survey work and with the development of rural development strategies, in order to minimise the risk of conservation having negative effects on local people's livelihoods. The outcomes of these botanical and socio-economic surveys can determine the conservation approach used, including more conventional approaches such as protected areas and *ex situ* conservation, but also exploring the many opportunities offered by conservation through use.
- As we showed in Chapter 7, CTU can only be depended on as a conservation strategy if certain conditions are met. When they are not, as for example with globally-important species that are not valued by local people or do not prosper in disturbed environments, or when favourable conditions of tenure and community organization do not exist, 'backstopping' strategies such as *ex situ* conservation or the establishment of protected areas may still be needed.

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Appendix 1. Comparing the conservation importance of different sites using the 'genetic heat index'

In Chapter 6 it was explained how different species were assigned discrete categories according to their priority for conservation. The criteria used in this study for this classification are presented in Table 3.3. However this species level classification is not alone sufficient to enable us to make direct comparisons between sites in terms of their conservation importance. How for example, can we decide whether a site that contains two species defined as being of Category B is of greater or lesser priority than one that contains a single Category A species? To achieve this, we need a form of weighting that provides us with a site-level index.

The method used in this study to address this has been developed from one first devised in Ghana by Hawthorne and Abu-Juam (1995)

The starting point in this method is for each category (here A, B, C or D) to be given a weighting or value that reflects its degree of conservation concern. This can then be used as the basis to calculate a numeric score (the GHI) for the entire site-level sample.

This is done in the following steps (see Table A.1 below):

1. Firstly, the area of occupancy of species in each category is estimated from distribution maps in botanical monographs by simply counting the number of degree squares occupied by each species. For the majority of species such maps are not available, so the average calculated for those that do is used for the rest.
2. Secondly, the ratios of the average areas of occupancy of each category is calculated by dividing each by the areas of occupancy of category D. Thus category D temporarily gets a score of 1.
3. These ratios are then inverted to give Category A the highest score, and each is rounded to the nearest integer.
4. Then, the Category D score is arbitrarily converted to zero, on the basis that species in this category are not of conservation concern and should not affect the index.
5. Genetic Heat Indices (GHI) are then calculated, based on these weightings, according to the following formula (where N is the total number of identified species in a sample):

$$GHI = \frac{[(\text{No Cat A spp} \times 32) + (\text{No of Cat B spp} \times 12) + (\text{No of Cat C spp} \times 5)] \times 100}{N}$$

Table A.1. Calculation of weightings for conservation categories

	A	B	C	D
1. Mean area of occupancy (No degree squares: n)	1.67	4.5	10.33	53.68
2. n/53.68 (=x)	0.031	0.084	0.192	1
3. 1/x	32.14	11.93	5.19	1
4. Rounded weighting	32	12	5	0

Two points should be made here. The weightings calculated as shown in Table A.1 are not universal: application of this methodology to different projects working in different regions will result in the calculated weighting for each category being different. This is due

to differences in the patterns of distribution of each species and the differences in the sizes of the geographical units (in this case states/countries) used for the initial delimitation of each of the categories (see table 7.2). However, once the weightings of categories are recalibrated for a different set of species in a different geographical region, the resulting GHIs could be compared with those given here.

Secondly, because in the GHI formula the denominator, N, is all species in the sample, an 'average' results that allows comparison of samples with different numbers of species. Ideally N should be reasonably large (› 30) to ensure GHIs are not overly sensitive to the inclusion or loss of single Category A or B species. However, here a minimum of 15 species is used in the analysis to ensure reasonable representation of some of the agricultural samples of low species richness.

The GHIs calculated as explained above allowed direct comparisons to be made of samples taken from different land uses in different countries and with different species.

Appendix 2. Species of Conservation Concern Found in the Oaxaca Study Area

CATEGORY A (including possible new species):

Carlowrightia sp. nov. ACANTHACEAE
Achatocarpus oaxacanus Standl. ACHATOCARPACEAE Mature forest fragments, occasionally fallows.
Licania sp. nov CHRYSOBALANACEAE
Trixis silvatica B.L.Rob. & Greenm. COMPOSITAE Mature forest fragments.
Jatropha alamani Muell.Arg. EUPHORBIACEAE Mature forest fragments and fallows.
Jatropha sympetala Standl. & Blake EUPHORBIACEAE Mature forest fragments and fallows.
Jatropha sp. nov. EUPHORBIACEAE
Manihot oaxacana D.J.Rogers & Appan Black. EUPHORBIACEAE Mature forest fragments and fallows.
Caesalpinia coccinea G.P.Lewis & J.L.Contr. LEGUMINOSAE-CAESALPINIOIDEAE Forest fragments and edges.
Mimosa albida Humb. & Bonpl. ex Willd. var. *pochutlensis* R.Grether LEGUMINOSAE-MIMOSOIDEAE. Disturbed forest fragments.
Zapoteca tehuana H.M.Hern. LEGUMINOSAE-MIMOSOIDEAE Mature forest fragments.
Lonchocarpus sp. nov. LEGUMINOSAE-PAPILIONOIDEAE
Bunchosia discolor Turcz. ex Char. MALPIGHIACEAE Mature forest fragments.
Megastigma sp. nov. RUTACEAE
Thouinia (undescribed species) SAPINDACEAE
Castela retusa Liebm. SIMAROUBACEAE Mature forest fragments.
Waltheria conzatii Standl. STERCULIACEAE Fallow.

CATEGORY B:

Sapranthus foetidus (Rose) Saff. ANNONACEAE Jalisco, Guerrero & Oaxaca. Mature forest fragments and fallows.
Bourreria purpusii Brandgee BORAGINACEAE Jalisco & Oaxaca. Mature forest fragments.
Forchhammeria lanceolata Standl. CAPPARIDACEAE Oaxaca & Guererro. Mature forest fragments and fallow.
Bucida wigginsiana Miranda COMBRETACEAE Guererro Oaxaca. Mature forest fragments.
Trixis pterocaulis B.L.Rob. & Greenm. COMPOSITAE Jalisco, Colima & Oaxaca. Mature semi-deciduous forest fragments.
Acalypha liebmannii (Muell.Arg.) Lundell EUPHORBIACEAE Oaxaca, Guerrero. Disturbed seasonal oak forest.
Caesalpinia hughesii G.P.Lewis LEGUMINOSAE-CAESALPINIOIDAE Oaxaca, Guererro & Colima. Forest fragments and edges.
Brongniartia bracteolata Micheli LEGUMINOSAE- PAPILIONOIDAE Oaxaca & Chiapas. Mature forest fragments, occasional fallows and farmland.
Lonchocarpus emarginatus Pittier LEGUMINOSAE-PAPILIONOIDAE Oaxaca & Chiapas. Mature forest fragments.
Lonchocarpus longipedicellatus Pittier LEGUMINOSAE-PAPILIONOIDAE Jalisco, Guererro & Oaxaca. Mature forest fragments.
Hibiscus kochii Fryxell MALVACEAE Guererro, Oaxaca. Mature forest fragments.
Eugenia salamensis Donn.Sm. var. *rensoniana* (Standl.) McVaugh MYRTACEAE Oaxaca Guatemala & Costa Rica. Mature forest fragments.

Guettarda galeottii Standl. RUBIACEAE Sinaloa, Nayarit & Oaxaca. Fallows.
Randia cinerea (Fernald) Standl. RUBIACEAE Oaxaca & Guererro. Fallows.
Recchia mexicana Moc. & Sessé SIMAROUBACEAE Oaxaca & Jalisco. Mature forest fragments, occasional fallows.
Physodium oaxacanum Dorr & Barnett STERCULIACEAE Oaxaca & Chiapas.
Triumfetta heliocarpoides Bullock TILIACEAE Guererro & Oaxaca. Seasonal oak forest.
Aloysia chiapensis Moldenke VERBENACEAE Oaxaca & Chiapas. Solar.

CATEGORY C:

Achatocarpus mexicanus H.Walter ACHATOCARPACEAE Chiapas & Oaxaca – not limited to Pacific dry forest. Mature forest fragments.
Lagrezia monosperma (Rose) Standl. AMARANTHACEAE Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments.
Actinocheita filicina (DC.) F.A.Barkley ANACARDIACEAE Guererro, Oaxaca, Chiapas & Puebla – not limited to Pacific dry forest. Disturbed forests and farmland.
Bursera aptera Ramirez BURSERACEAE Guererro, Oaxaca, Puebla & Morelos – not limited to pacific dry forest. Mature forest fragments.
Bursera instabilis McVaugh & Rzed. BURSERACEAE Nayarit, Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments.
Capparis angustifolia Kunth CAPPARIDACEAE Guererro & Oaxaca. Mature forest fragments.
Bucida macrostachya Standl. COMBRETACEAE Oaxaca, Chiapas, Belize, Guatemala, Honduras & Nicaragua. Mature forest fragments, occasional fallows.
Chromolaena glaberrima (DC.) R.M.King & H.Rob. COMPOSITAE Oaxaca – not limited to Pacific dry forest. Principally oak forest.
Montanoa tomentosa Cerv. ssp. *microcephala* (Sch.Bip.) V.A.Funk COMPOSITAE Oaxaca – not limited to Pacific dry forest. Principally seasonal oak forest.
Verbesina oaxacana DC. COMPOSITAE Oaxaca – not limited to Pacific dry forest. Fallows.
Croton axillaris Muell.Arg. EUPHORBIACEAE Oaxaca, Chiapas, San Luis Potosí, Tamaulipas, Guatemala Nicaragua Costa Rica. Mature forest fragments.
Croton ramillatus Croizat EUPHORBIACEAE Guererro Oaxaca Veracruz – not limited to Pacific dry forest. Mature forest fragments.
Croton septemnervius McVaugh EUPHORBIACEAE Jalisco Guererro Oaxaca – not limited to Pacific dry forest. Mature forest fragments and fallows.
Casearia williamsiana Sleumer FLACOURTIACEAE Honduras – not limited to Pacific dry forest. Disturbed forest fragments.
Samyda mexicana Rose FLACOURTIACEAE Jalisco, Guererro, Oaxaca, Veracruz – not limited to Pacific dry forest Mature forest fragments.
Gyrocarpus mocinnoi Espejo HERNANDIACEAE Guererro, Chiapas, Oaxaca, Puebla & Guatemala. Mature forest fragments and fallows.
Hyptis tomentosa Poit. LABIATAE Oaxaca, Chiapas, Veracruz – not limited to Pacific dry forest. Mature forest fragments, fallows and farmland.
Caesalpinia mollis (Kunth) Spreng. LEGUMINOSAE-CAESALPINIODEAE – not limited to Pacific dry forest.
Cynometra oaxacana Brandegee LEGUMINOSAE-CAESALPINIODEAE Jalisco, Colima, Guererro, Oaxaca & Chiapas. Mature forest fragments.

Calliandra hirsuta (G.Don) Benth. LEGUMINOSAE-MIMOSOIDAE Guererro, Oaxaca, Chiapas, Puebla – not limited to Pacific dry forest. Farm land.

Havardia campylacanthus (L.Rico & M.Sousa) Barneby & J.W.Grimes LEGUMINOSAE-MIMOSOIDAE Michoacan, Guererro, Oaxaca Belize, Nicaragua & Honduras. Forest fragments and farmland.

Mimosa eurycarpa B.L.Rob. LEGUMINOSAE-MIMOSOIDAE Michoacan, Colima, Oaxaca – not limited to Pacific dry forest. Mature forest fragments.

Mimosa robusta R.Grether LEGUMINOSAE-MIMOSOIDAE Farmland.

Indigofera platycarpa Rose LEGUMINOSAE-PAPILIONOIDAE Guererro Oaxaca Pue Mor – not limited to Pacific dry forest. Mature forest fragments.

Lonchocarpus constrictus Pittier LEGUMINOSAE-PAPILIONOIDAE Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments and occasionally forests.

Platymiscium lasiocarpum Sandwith LEGUMINOSAE-PAPILIONOIDAE Jalisco Michoacan Guererro Oaxaca – not limited to Pacific dry forest. Mature forest fragments

Abutilon grandidentatum Fryxel. MALVACEAE Oaxaca, Chiapas – not limited to Pacific dry forest. Mature forest fragments.

Hibiscus peripteroides Fryxell MALVACEAE Oaxaca, San Luis Potosí – not limited to Pacific dry forest. Reverine forest.

Torrubia macrocarpa Miranda NYCTAGINACEAE Oaxaca Mature forest fragments, occasionally farmland.

Chiococca filipes Lundell RUBIACEAE Oaxaca, Chiapas & Honduras – not limited to Pacific dry forest. Seasonal oak forest.

Randia nelsonii Greenm. RUBIACEAE Sinaloa, Michoacan Oaxaca & Veracruz – not limited to Pacific dry forest. Mature forest fragments.

Rondeletia deamii (Donn.Sm) Standl. RUBIACEAE Oaxaca, Guatemala, Honduras & Nicargua – not limited to Pacific dry forest. Forest fragments and farmland.

Heliocarpus occidentalis Rose TILIACEAE Guererro & Oaxaca. Mature forest fragments.

Appendix 3. Species of conservation concern found in the Honduran study area

CATEGORY A:

None

CATEGORY B:

Leucaena salvadorensis Standl. LEGUMINOSAE-MIMOSOIDAE El Salvador, Nicaragua & Honduras. Disturbed forest fragments and farmland.

Eugenia hondurensis Ant. Molina MYRTACEAE Honduras & Nicaragua. Disturbed forests and farmland.

Grajalesia fasciculata (Standl.) Miranda NYCTAGINACEAE Guatemala ELS Honduras Nicaragua. Disturbed forest and farmland.

Guettarda deamii Standl. RUBIACEAE Guatemala, El Salvador, Honduras Nicaragua. Disturbed forest fragments.

CATEGORY C:

Persea caerulea (Ruiz & Pav.) Mez LAURACEAE El Salvador, Honduras Nicaragua Costa Rica & Panama. Disturbed forest fragments.

Casearia williamsiana Sleumer FLACOURTIACEAE Honduras, Nicaragua – not limited to Pacific dry forest. Disturbed forest fragments.

Mimosa panamensis (Benth.) Standl. LEGUMINOSAE-MIMOSOIDAE Honduras & Panama – not limited to Pacific dry forest Farmland.

Bunchosia guatemalensis Ndzu MALPIGHIACEAE Chiapas, Guatemala & Honduras – not limited to Pacific dry forest. Disturbed forest fragments.

Randia pleiomeris Standl. RUBIACEAE Guatemala, El Salvador & Honduras – not limited to Pacific dry forest. Disturbed forest fragments and farmland.

Rondeletia deamii (Donn.Sm) Standl. RUBIACEAE Oaxaca, Guatemala, Honduras & Nicaragua – not limited to Pacific dry forest. Forest fragments and farmland.

Trigonia rugosa Benth. TRIGONIACEAE Guatemala El Salvador, Honduras & Nicuargua – not limited to Pacific dry forest Disturbed forest fragments.

IUCN Categories:

Vulnerable

Bombacopsis quinata (Jacq.) Dugand. BOMBACACEAE Disturbed forest fragments, occasionally farmland.

Endangered

Guaiacum sanctum L. ZYGOPHYLLACEAE Disturbed forest fragments.

Appendix 4. Checklist of woody species for Oaxacan and Honduran Pacific Coast dry forests

A. Reyes-García, G. Sandoval, J. E. Gordon

The species listed were found during surveys of dry forest fragments and farmland in southern Honduras and southern Oaxaca, Mexico from 1998-2000. The definition of a woody species included any individual found unsupported with woody stem of at least 1cm diameter at ground level. Thus although lianas are not generally included, in some cases species known as lianas are listed because they were found in free-standing habit. Species known to be exotic are included and are marked with an asterisk. It includes species from samples from deciduous oak forest in Oaxaca, a forest type not usually considered dry forest. The familial and generic organisation of the list follows Mabberley (1997)* except where noted. Vouchers were deposited in the National Herbarium, Mexico City (MEXU) and the Paul C. Standley Herbarium, El Zamorano, Honduras (EAP).

Each species listed is preceded by H, O or H O depending upon whether it was found in Honduras, Oaxaca or both, respectively. Species of conservation concern are in bold. The conservation status was either determined with reference to IUCN lists (Oldfield et al 1998) or by a modification of the Star system (Hawthorne 1996) described elsewhere in this volume. In the latter case the estimated distribution of Class B and Class C species, on which the ranking is based, is noted. This is not done for Class A which by definition are endemic to the dryforest areas of the area in which they were found. The habitat type in which these species were found is also noted.

The following abbreviations are used to describe distribution of species of conservation concern: PDF- Pacific dry forest. Sin- Sinaloa; Jal- Jalisco; Mich- Michoacan; Col- Colima; Nay- Nayarit; Gro- Guerrero; Oax- Oaxaca; Chis- Chiapas; SLP- San Luis Potosí; Mor- Morelos; Pue- Puebla; Tam- Tamaulipas; Ver- Veracruz; Yuc- Yucatán; Qroo- Quintana Roo; Bel- Belize; Guat- Guatemala; ELS- El Salvador; Hon- Honduras; Nic- Nicaragua; CR- Costa Rica; Pan- Panama.

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* Mabberley, D.J. (1997). The Plant-Book (2nd edition). Cambridge, Cambridge University Press.

Acanthaceae

H *Aphelandra aurantiaca* (Scheidw.) Lindl.
H O *Aphelandra scabra* (Vahl) Sm.
O *Barleria micans* Nees
O *Justicia caudata* A.Gray
H *Odontonema callistachyum* (Schltdl. & Cham.) Kuntze[1]

Achatocarpaceae

O *Achatocarpus gracilis* H.Walter
O ***Achatocarpus mexicanus*** H.Walter Category C (Chis Oax – not limited to PDF). Mature forest fragments.
O ***Achatocarpus oaxacanus*** Standl. Category A. Mature forest fragments, occasionally fallows.

Amaranthaceae

O *Alternanthera pyncantha* (Benth.) Standl.
H O *Celosia argentea* L.
H *Celosia virgata* Jacq.
O *Iresine calea* (Ibáñez) Standl.
H O *Iresine diffusa* Willd.
O ***Lagrezia monosperma*** (Rose) Standl. Category C (Jal Mich Col Gro Oax). Mature forest fragments.

Anacardiaceae

H ***Actinocheitia filicina*** (DC.) F.A.Barkley Category C (Gro Oax Chis Pue – not limited to PDF). Disturbed forests and farmland.
O *Amphipterygium adstringens* (Schltdl.) Standl.
H *Anacardium excelsium* (Bert. & Balb.) Skeels
H O *Anacardium occidentale* L.
H O *Astronium graveolens* Jacq.
O *Comocladia engleriana* Loes.
H O **Mangifera indica* L.
O *Pseudosmodingium multifolium* Rose
H O *Spondias purpurea* L.

Annonaceae

O *Annona cherimola* Mill.
O *Annona diversifolia* Saff.
H O *Annona glabra* L.
H *Annona holosericea* Saff.
H O *Annona muricata* L.
H *Annona purpurea* L.
H O *Annona reticulata* L.
H O *Annona squamosa* L.
O ***Sapranthus foetidus*** (Rose) Saff. Category B (Jal Gro Oax). Mature forest fragments and fallows.
H O *Sapranthus microcarpus* (Donn.Sm.) R.E.Fries
H *Sapranthus violaceus* (Dunal) Saff.

Apocynaceae

H O *Plumeria rubra* L.
O *Rauvolfia ligustrina* Roem. & Schult.
H O *Rauvolfia tetraphylla* L.
H O *Stemmadenia obovata* (Hook. & Arn.) K.Schum.
O *Tabernaemontana amygdalifolia* Jacq.
O *Tabernaemontana divaricata* R.Br. ex Roem. & Schult.
H *Thevetia gaumeri* Hemsl.
H O *Thevetia ovata* (Cav.) A.DC.
H O *Thevetia peruviana* (Pers.) K.Schum.
O *Thevetia thevetioides* (Kunth) K.Schum.

Araliaceae

H O *Dendropanax arboreum* (L.) Decne. & Planch.
H *Sciadodendron excelsum* Griseb.

Asclepiadaceae

H **Calotropsis procera* (Aiton) Aiton f.
H **Cryptostegia madagascariensis* Bojer & Decne.
H *Matelea prosthecidiscus* Woodson

Bignoniaceae

O *Astianthus viminalis* (Kunth) Baill.
H *Crescentia alata* Kunth
H O *Crescentia cujete* L.
H O *Godmania aesculifolia* (Kunth) Standl.
H **Jacaranda mimosaefolia* D.Don.
H *Lundia puberula* Pittier
O *Parmentiera aculeata* (Kunth) Seem.

H O **Spathodea campanulata* Beauv.
O *Tabebuia impetiginosa* (Mart. ex DC.) Standl.
H O *Tabebuia ochracea* (Cham.) Standl. ssp. *neochrysantha* (A. Gentry) A. Gentry
H O *Tabebuia rosea* (Bertol.) DC.
H O *Tecoma stans* (L) Juss. ex Kunth

Bixaceae

H O *Bixa orellana* L.
H O *Cochlospermun vitifolium* (Willd.) Spreng.

Bombacaceae

H ***Bombacopsis quinata*** (Jacq.) Dugand. [= Pachira quinata (Jacq.) W. S. Alverson Vulnerable. Disturbed forest fragments, occasionally farmland.
H O *Ceiba aesculifolia* (Kunth) Britton & Baker f.
O *Ceiba parvifolia* Rose
H O *Ceiba pentandra* (L.) Gaertn.
O *Pseudobombax ellipticum* (Kunth) Dugand

Boraginaceae

O ***Bourreria purpusii*** Brandgee Category B (Jal Oax). Mature forest fragments.
H O *Cordia alliodora* (Ruiz & Pav.) Oken
H *Cordia collococca* L.
H O *Cordia curassavica* (Jacq.) Roem. & Schult.
H O *Cordia dentata* Poir
O *Cordia elaeagnoides* A.DC.
H *Cordia gerascanthus* L.
O *Cordia globosa* (Jacq.) Kunth
H *Cordia inermis* (Mill.) I.M.Johnst.
H *Cordia nitida* Vahl
O *Cordia seleriana* Fernald
O *Tournefortia hirsutissima* L.

Buddlejaceae

H O *Buddleja americana* L.

Burseraceae

O ***Bursera aptera*** Ramirez Category C (Gro Oax Pue Mor – not limited to PDF). Mature forest fragments.
O *Bursera arborea* (Rose) L.Riley
O *Bursera bipinnata* (Sessé & Moc. ex DC.) Engl.
O *Bursera copallifera* (Sessé & Moc. ex DC.) Bullock
O *Bursera excelsa* (Kunth) Engl.
O *Bursera fagaroides* (Kunth) Engl.
H *Bursera graveolens* (Kunth) Triana & Planch.
O *Bursera heteresthes* Bullock
O ***Bursera instabilis*** McVaugh & Rzed. Category C (Nay Jal Mich Col Gro Oax). Mature forest fragments.
O *Bursera lancifolia* (Schltdl.) Engl.
O *Bursera longipes* (Rose) Standl.
O *Bursera schlechtendalii* Engl.
H O *Bursera simaruba* (L.) Sarg.

Cactaceae

H *Pereskia autumnalis* (Eichlam.) Britton & Rose
O *Pereskia lychnidiflora* DC.
O *Pereskiopsis diguetti* (F.A.C.Weber) Britton & Rose

Capparidaceae

O ***Capparis angustifolia*** Kunth Category B (Mich Gro Oax). Mature forest fragments.
O *Capparis baduca* L.
O *Capparis flexuosa* (L.) L.
H *Capparis frondosa* Jacq.
O *Capparis incana* Kunth
H O *Capparis indica* (L.) Druce
O *Capparis odoratissima* Jacq.
O *Capparis verrucosa* Jacq.
O *Cleome pilosa* Benth.
O *Crataeva tapia* L.
O ***Forchhammeria lanceolata*** Standl. Category B (Oax Gro). Mature forest fragments and fallow.
O *Forchhammeria pallida* Liebm.
H O *Morisonia americana* L.

Caricaceae

H O *Carica papaya* L.

O *Jacaratia mexicana* A.DC.

Cecropiaceae
O *Cecropia obtusifolia* Bertol.
H *Cecropia peltata* L.

Celastraceae
O *Crossopetalum uragoga* (Jacq.) Kuntze
O *Hippocratea acapulcensis* Kunth
O *Hippocratea celastroides* Kunth

Chrysobalanaceae
H O *Chrysobalanus icaco* L.
H *Couepia polyandra* (Kunth) Rose
H O *Licania arborea* Seem.
H O *Licania platypus* (Kunth) Rose

Clethraceae
See Cyrillaceae

Cochlospermaceae
See Bixaceae

Combretaceae
O ***Bucida macrostachya*** Standl.
Category C (Oax Chis Bel Guat Hon Nic). Mature forest fragmentss, occasional fallows.
O ***Bucida wigginsiana*** Miranda
Category B (Gro Oax) Mature forest fragments.
O **Terminalia catappa* L.

Compositae
O ***Chromolaena glaberrima*** (DC.) R.M.King & H.Rob.
Category C (Oax – not limited to PDF). Principally oak forest.
H *Eleutheranthera ruderalis* (Sw.) Sch.Bip.
O *Eupatorium scabrellum* B.L.Rob.
O *Lagascea helianthifolia* Kunth
O *Lasianthaea fruticosa* (L.) K.M.Becker var. *michoacana* (Blake) K.M.Becker
O *Montanoa grandiflora* Alaman ex DC.
O *Montanoa speciosa* DC.
O ***Montanoa tomentosa*** Cerv. ssp. ***microcephala*** (Sch.Bip.) V.A.Funk
Category C (Oax – not limited to PDF). Principally seasonal oak forest.
H *Polymnia maculata* Cav.
O *Roldana eriophylla* (Greenm.) H.Rob. & Brettell
O *Trixis inula* Crantz
O *Trixis mexicana* Lex.
O ***Trixis pterocaulis*** B.L.Rob. & Greenm.
Category B (Sin Jal Col Oax). Mature semi-deciduous forest fragments.
O ***Trixis silvatica*** B.L.Rob. & Greenm.
Category A. Mature forest fragments.
O *Verbesina fastigiata* B.L.Rob. & Greenm.
H *Verbesina gigantea* Jacq.
H *Verbesina gigantoides* B.L.Rob.
O ***Verbesina oaxacana*** DC.
Category C (Oax – not limited to PDF) Fallows.
O *Verbesina turbacensis* Kunth
H O *Vernonanthera patens* (Kunth) H. Rob
O *Vernonia triflosculosa* Kunth var. *palmeri* (Rose) B.L.Turner

Convolvulaceae
O *Ipomoea wolcottiana* Rose

Cyrillacaea
O *Clethra mexicana* DC.

Dilleniaceae
H O *Curatella americana* L.

Ebenaceae
O *Diospyros digyna* Jacq.
H O *Diospyros salicifolia* Humb. & Bonpl. ex Willd.

Erythroxylaceae
H *Erythroxylum areolatum* L.
O *Erythroxylum havanense* Jacq.
O *Erythroxylum rotundifolium* Lunan

Euphorbiaceae
O ***Acalypha liebmannii*** (Muell. Arg.) Lundell

Category B (Oax Gro). Seasonal oak forest.
H O *Acalypha schiedeana* Schltdl.
H *Cnidoscolus aconitifolius* (Mill.) I.M.Johnst.
H O *Cnidoscolus tubulosus* (Muell. Arg.) I.M.Johnst.
O ***Croton axillaris*** Muell. Arg.
Category C (Oax Chis SLP Tam Guat Nic CR). Mature forest fragments.
H *Croton cortesianus* Kunth
O *Croton fragilis* Kunth
H *Croton guatemalensis* Lotsy
O *Croton niveus* Jacq.
H *Croton payaquensis* Standl.
O ***Croton ramillatus*** Croizat
Category C (Gro Oax Ver – not limited to PDF). Mature forest fragments.
O *Croton rhamifolius* Kunth
O ***Croton septemnervius*** McVaugh
Category C (Jal Gro Oax – not limited to PDF). Mature forest fragments and fallows.
O *Croton suberosus* Kunth
O *Euphorbia colletioides* Benth.
O *Euphorbia pulcherrima* Willd. ex Klotzsch
O *Euphorbia scabrella* Boiss.
H O *Euphorbia schlechtendalii* Boiss.
O *Garcia nutans* Vahl
O ***Jatropha alamani*** Muell. Arg.
Category A Mature forest fragments and fallows.
H O *Jatropha curcas* L.
H *Jatropha gossypifolia* L.
O *Jatropha malacophylla* Standl.
O ***Jatropha sympetala*** Standl. & Blake
Category A Mature forest fragments and fallows.
H O *Manihot aesculifolia* (Kunth) Pohl
O *Manihot chlorosticta* Standl. & Goldman
O *Manihot dulcis* (J.F.Gmel.) Pax
O ***Manihot oaxacana*** D.J.Rogers & Appan
Category A Mature forest fragments and fallows.
H *Margaritaria nobilis* L.f.
O *Pedilanthus tithymaloides* (L.) Poit.
H *Phyllanthus acuminatus* Vahl
O *Phyllanthus mocinianus* Baill.
O *Phyllanthus nobilis* (L. f.) Muell. Arg.
H O **Ricinus communis* L.
O *Sapium lateriflorum* Hemsl.
O *Sapium macrocarpum* Muell.

Fagaceae

O *Quercus acutifolia* Née
O *Quercus magnoliifolia* Née
O *Quercus obtusata* Humb.& Bonpl.
H *Quercus oleoides* Schltdl. & Cham.
O *Quercus peduncularis* Née

Flacourtiaceae

O *Casearia aculeata* Jacq.
O *Casearia arguta* Kunth
H O *Casearia corymbosa* Kunth
H O *Casearia sylvestris* Swartz. var. *sylvestris*
O *Casearia tremula* Griseb. ex C.Wright
H ***Casearia williamsiana*** Sleumer
Category C (Hon, Nic- not endemic to PDF) Disturbed forest fragments.
O *Homalium racemosum* Jacq.
H O *Prockia crucis* P.Browne ex L.
O ***Samyda mexicana*** Rose
Category C (Jal Gro Oax Ver – not limited to PDF) Mature forest fragnments.
H O *Xylosma flexuosa* (Kunth) Hemsl.

Guttiferae

H O *Calophyllum brasiliense* Cambess. var. *rekoi* Standl.
H *Clusia lundellii* Standl.
H *Rheedia intermedia* Pittier
O *Vismia mexicana* Schltdl.

Hernandiaceae

H *Gyrocarpus americanus* Jacq.
O *Gyrocarpus jatrophifolius* Domin
O ***Gyrocarpus mocinnoi*** Espejo
Category C (Oax Gro Chis Pue Guat). Mature forest fragments and fallows.

Hippocrateceae

See Celastraceae

Hydrophyllaceae

O *Wigandia urens* (Ruiz & Pav.) Kunth

Julianaceae

See Anacardiaceae

Labiatae

H *Callicarpa acuminata* Kunth
H *Cornutia pyramidata* L.
O ***Hyptis tomentosa*** Poit.
Category C (Oax Chis Ver – not limited to PDF) Mature forest fragments, fallows and farmland.
H *Salvia tiliaefolia* Vahl
H **Tectona grandis* L.
H *Vitex gaumeri* Greenm.
O *Vitex hemsleyi* Briq.
O *Vitex mollis* Kunth
O *Vitex pyramidata* Rob.

Lauraceae

H **Cinnamomum zeylanicum* Nees
O *Nectandra salicifolia* (Kunth) Nees
H O *Persea americana* Mill.
H ***Persea caerulea*** (Ruiz & Pav.) Mez
Category C (ELS Hon Nic CR Pan) Disturbed forest fragments.
O *Phoebe cinnamomifolia* (Kunth) Nees

Leguminosae (Caesalpinioideae)

O *Bauhinia divaricata* L.
H *Bauhinia pauletia* Pers.
O *Bauhinia subrotundifolia* Cav.
H O *Bauhinia ungulata* L.
O ***Brongniartia bracteolata*** Micheli
Category B (Oax Chis). Mature forest fragments, occasional fallows and farmland.
O ***Caesalpinia coccinea*** G.P.Lewis & J.L.Contr.
Category A. Forest fragments and edges.
H O *Caesalpinia coriaria* (Jacq.) Willd.
H O *Caesalpinia eriostachys* Benth.
O *Caesalpinia exostemma* DC.
O ***Caesalpinia hughesii*** G.P.Lewis
Category B (Oax Gro Col). Forest fragments and edges.
O ***Caesalpinia mollis*** (Kunth) Spreng.
Category C (Oax Chis Yuc -not endemic to PDF).
O *Caesalpinia platyloba* S.Watson
H O *Caesalpinia pulcherrima* (L.) Sw.
O *Caesalpinia sclerocarpa* Standl.
O *Caesalpinia velutina* (Britton & Rose) Standl.
H *Cassia grandis* L.
H **Cassia siamea* Lam.
O *Chamaecrista nictitans* (L.) Moench. var. *jaliscensis* (Greemn.) Irwin & Barneby
O ***Cyanometra oaxacana*** Brandegee
Category C (Jal Col Gro Oax Chis). Mature forest fragments.
H O *Delonix regia* (Bojer & Hook.) Raf.
H *Haematoxylum brasiletto* H.Karst.
H O *Hymenea courbaril* L.
H *Parkinsonia aculeata* L.
H O *Poeppigia procera* (Spreng.) C.Presl.
H O **Senna alata* (L.) Roxb.
O *Senna atomaria* (L.) Irwin & Barnaby
H *Senna emarginata* (L.) Irwin & Barneby
O *Senna fruticosa* (Mill.) Irwin & Barneby
H O *Senna holwayana* (Rose) Irwin & Barneby
O *Senna mollissima* (Willd.) Irwin & Barneby
O *Senna nicaraguensis* (Benth.) Irwin & Barneby
H *Senna occidentalis* (L.) Link
H O *Senna pallida* (Vahl) Irwin & Barnaby
O *Senna quinquangulata* (L.C.Rich) Irwin & Barneby
H *Senna skinneri* (Benth.) Irwin & Barnaby
O *Senna uniflora* (Mill.) Irwin & Barneby
H O **Tamarindus indica* L.

Leguminosae (Mimosoideae)

H O *Acacia angustissima* (Mill.) Kuntze
O *Acacia cochliacantha* Humb. & Bonpl. Ex Willd
H O *Acacia collinsii* Saff.
H O *Acacia cornigera* (L.) Willd.
H O *Acacia farnesiana* (L.) Willd.
H O *Acacia hindsii* Benth.
O *Acacia macrocantha* Humb. & Bonpl. ex Willd.

H **Acacia mangium*
O *Acacia pennatula* (Cham. & Schltdl.) Benth.
O *Acacia picachensis* Brandegee
H O *Albizia adinocephala* (Donn.Sm.) Britton & Rose
H O *Albizia guachapele* (Kunth.) Harms [=Pseudosamanea guachapele (Kunth) Harms]
O *Albizia occidentalis* Brandegee [=Hesperalbizia occidentalis (Brandegee) Barneby & J.W.Grimes]
H *Albizia niopoides* (Benth.) Burkart var. *niopoides*
H *Albizia saman* (Jacq.) F. Muell. [=Samanea saman (Jacq.) Merill]
O *Calliandra acapulcensis* Britton & Rose
O *Calliandra emarginata* (Humb. Ex Willd.) Benth.
O ***Calliandra hirsuta*** (G.Don) Benth. Category C (Gro Oax Chis Pue – not limited to PDF). Farm land.
O *Calliandra houstoniana* (Mill.) Standl.
O *Calliandra tergemina* (L.) Benth.
H O *Chloroleucon mangense* (Jacq.) Britton & Rose var. *leucospermum* (Brandegee) Barneby & J.W.Grimes
H O *Enterolobium cyclocarpum* (Jacq.) Griseb.
O ***Havardia campylacanthus*** (L.Rico & M.Sousa) Barneby & J.W.Grimes Category C (Mich Gro Oax Bel Nic Hon). Forest fragments and farmland.
H *Inga sapindoides* Willd.
H O *Inga vera* Willd.
O *Leucaena esculenta* (Sessé & Moc. ex DC.) Benth.
O *Leucaena lanceolata* S.Watson var. *sousae* (S. Zárate) C.E.Hughes
H O *Leucaena leucocephala* (Lam.) de Wit
O *Leucaena macrophylla* Benth.
H ***Leucaena salvadorensis*** Standl. Category B (ELS Nic Hon). Distrubed forest fragments and farmland.
H *Leucaena shannonii* Donn.Sm.
H O *Lysiloma acapulcense* (Kunth) Benth.
H O *Lysiloma auritum* (Schltdl.) Benth.
H O *Lysiloma divaricatum* (Jacq.) J.F.Macbr.
H O *Mimosa albida* Humb. & Bonpl. ex Willd.
O ***Mimosa albida*** Humb. & Bonpl. ex Willd. var. ***pochutlensis*** R.Grether Category A. Disturbed forest fragments.
O *Mimosa arenosa* (Willd.) Poir.
O ***Mimosa eurycarpa*** B.L.Rob. Category C (Mich Col Oax – not limited to PDF). Mature forest fragments.
H ***Mimosa panamensis*** (Benth.) Standl. Category C (Hon Pan – not limited to PDF). Farmland.
H O *Mimosa platycarpa* Benth.
H *Mimosa pudica* L.
O ***Mimosa robusta*** R.Grether Category C (Jal Nay Gro Oax – not limited to PDF) Farmland.
H *Mimosa somnians* Humb. & Bonpl. ex Willd.
H O *Mimosa tenuiflora* (Willd.) Poir.
O *Piptadenia flava* (Spreng. ex DC.) Benth.
O *Piptadenia obliqua* (Pers.) J.F.Macbr.
H O *Pithecellobium dulce* (Roxb.) Benth.
O *Pithecellobium lanceolatum* (Humb. & Bonpl. ex Willd.) Benth.
O *Pithecellobium seleri* Harms
O *Prosopis juliflora* (Sw.) DC.
O *Zapoteca formosa* (Kunth) H.M.Hern. ssp. *rosei* (Wiggins) H.M.Hern.
O *Zapoteca formosa* (Kunth) H.M.Hern. ssp. *formosa*
O ***Zapoteca tehuana*** H.M.Hern. Category A. Mature forest fragments.

Leguminosae (Papilionoideae)

H *Acosmium panamense* (Benth.) Yakoul
O *Aeschynomene americana* L.
O *Aeschynomene compacta* Rose
O *Aeschynomene fascicularis* Schltdl. & Cham.
H O *Andira inermis* (Wright) Kunth
O *Apoplanesia paniculata* C.Presl.
O *Coursetia caribaea* (Jacq.) Lavin var. *serica* (A.Gray) Lavin
O *Coursetia glandulosa* A.Gray
H O *Coursetia polyphylla* Brandegee
H *Dalbergia glabra* (Mill.) Standl.

O *Dalbergia granadillo* Pittier
O *Dalea carthagenensis* (Jacq.) J.F.Macbr.
H *Dalea scandens* (Mill.) R.T.Clausen
O *Desmodium nicaraguense* Benth.
H *Erythrina fusca* Lour.
O *Erythrina lanata* Rose
H O *Gliricidia sepium* (Jacq.) Steud.
O *Hybosema ehrenbergii* (Schltdl.) Harms[2]
O *Indigofera fruticosa* Rose
O *Indigofera lancifolia* Rydb.
O *Indigofera panamensis* Rydb.
O ***Indigofera platycarpa*** Rose
Category C (Gro Oax Pue Mor – not limited to PDF). Mature forest fragments.
O *Lonchocarpus acuminatus* (Schltdl.) Sousa
O ***Lonchocarpus constrictus*** Pittier
Category C (Jal Mich Col Gro Oax). Mature forest fragments and occasionally fallows.
O ***Lonchocarpus emarginatus*** Pittier
Category B (Oax Chis). Mature forest fragments.
H O *Lonchocarpus guatemalensis* Benth.
O *Lonchocarpus hermanii* M.Sousa
O *Lonchocarpus lanceolatus* Benth.
O ***Lonchocarpus longipedicellatus*** Pittier
Category B (Jal Gro Oax). Mature forest fragments.
H *Lonchocarpus minimiflorus* Donn.Sm.
H O *Lonchocarpus phaseolifolius* Benth.
H O *Lonchocarpus rugosus* Benth.
O *Lonchocarpus rugosus* Benth. ssp. *apricus* (Lundell) M.Sousa
H O *Machaerium biovulatum* Micheli
O *Machaerium salvadorense* (Donn.Sm.) Rudd
H O *Myrospermun frutescens* Jacq.
O *Piscidia carthagenensis* Jacq.
O *Piscidia grandifolia* (Donn.Sm.) I.M.Johnst.
H O *Platymiscium dimorphandrum* Donn.Sm.
O ***Platymiscium lasiocarpum*** Sandwith
Category C (Jal Mich Gro Oax – not limited to PDF). Mature forest fragments
O *Pterocarpus acapulcensis* Rose
O *Pterocarpus rohrii* Vahl
O *Tephrosia leiocarpa* A.Gray
O *Tephrosia multifolia* Rose

Loganiaceae
See Buddlejaceae

Lythraceae
O *Adenaria floribunda* Kunth
H **Lawsonia inermis* L.
H *Pehria compacta* (Rusby) Sprague

Malpighiaceae
O *Bunchosia caroli* W. R. Anderson
O ***Bunchosia discolor*** Turcz. ex Char.
Category A. Mature forest fragments.
H ***Bunchosia guatemalensis*** Ndzu
Category C (Chis Guat Hon – not limited to PDF). Disturbed forest fragments.
H *Bunchosia odorata* (Jacq.) Kunth
H O *Byrsonima crassifolia* (L.) Kunth
H O *Heteropterys laurifolia* (L.) A.Juss.
H *Hiraea velutina* Nied.
O *Malpighia emarginata* DC.
O *Malpighia glabra* L.
O *Malpighia ovata* Rose
H *Tetrapterys arcana* Morton

Malvaceae
O **Abelmoschus esculentus* (L.) Moench
O ***Abutilon grandidentatum*** Fryxel.
Category C (Oax Chis – not limited to PDF). Mature forest fragments.
H *Abutilon hirtum* (Lam.) Sweet
O **Gossypium arboreum* L.
O *Gossypium aridum* (Rose & Standl.) Skov.
H O *Gossypium hirsutum* L.
O *Gossypium irenaeum* Lewton
O ***Hibiscus kochii*** Fryxell
Category B (Gro Oax.). Mature forest fragments.
O ***Hibiscus peripteroides*** Fryxell
Category C (Oax SLP – not limited to PDF). Reverine forest.
O *Hibiscus sabdariffa* L.
H O *Malvaviscus arboreus* Cav.
H O *Sida acuta* Burm.f.
O *Sida cordifolia* L.
H *Sida paniculata* L.

O *Sida rhombifolia* L.

Melastomataceae
H *Conostegia subcrustulata* (Beurl.) Triana
O *Conostegia xalapensis* (Bonpl.) D.Don ex DC.
H *Miconia albicans* (Sw.) Triana
H *Miconia argentea* (Sw.) DC.

Meliaceae
H O **Azadirachta indica* A.Juss.
H O *Cedrela odorata* L.
H O *Guarea glabra* Vahl
O **Melia azadirachta* L.
H O ***Swietenia humilis*** Zucc.
Vulnerable. Forests and farmland.
O *Swietenia macrophylla* G. King
H *Trichilia americana* (Sessé & Moc.) T.D.Penn
O *Trichilia havanensis* Jacq.
H O *Trichilia hirta* L.
H O *Trichilia martiana* C.DC.
H O *Trichilia trifolia* L.

Menispermaceae
O *Hyperbaena mexicana* Miers

Monimiaceae
H *Siparuna nicaraguensis* Hemsl.

Moraceae
H **Artocarpus altilis* (Parkinson) Fosberg
H O *Brosimum alicastrum* Sw.
H *Castilla elastica* Sessé ex Cerv.
H *Ficus americana* Aubl.
H O *Ficus benjamina* L.
O *Ficus calyculata* Mill.
O *Ficus cotinifolia* Kunth
H *Ficus glabrata* Kunth
O *Ficus goldmanii* Standl.
O *Ficus insipida* Willd.
H O *Ficus maxima* Mill.
H O *Ficus obtusifolia* Kunth
H O *Ficus ovalis* (Liebm.) Miq.
O *Ficus pertusa* L.f.
O *Ficus petiolaris* Kunth
O *Ficus subrotundifolia* Greenm.
O *Ficus trigonata* L.
H O *Maclura tinctoria* (L.) D. Don ex Steud.
O *Trophis racemosa* (L.) Urb.

Myrsinaceae
O *Ardisia compressa* Kunth
H O *Ardisia revoluta* Kunth

Myrtaceae
H *Eugenia acapulcensis* Steud.
O *Eugenia farameoides* A.Rich.
H ***Eugenia hondurensis*** Ant. Molina
Category B (Oax? Hon Nic). Disturbed forests and farmland.
O ***Eugenia salamensis*** Donn.Sm. var. ***rensoniana*** (Standl.) McVaugh
Category B (Oax Guat CR). Mature forest fragments.
H O *Psidium guajava* L.
H O *Psidium guineense* Sw.
O *Psidium sartorianum* (O.Berg) Nied.

Nyctaginaceae
H O *Bougainvillea x buttiana* Holt. & Standl.
H ***Grajalesia fasciculata*** (Standl.) Miranda
Category C (Oax Guat ELS Hon Nic). Disturbed forest and farmland.
H O *Neea psychotrioides* Donn.Sm.
O *Pisonia aculeata* L.
O *Salpianthus arenarius* Humb. & Bonpl.
O ***Torrubia macrocarpa*** Miranda [=Guapira macrocarpa Miranda?]
Category C (Jal Mich Mor Oax Pue) Mature forest fragments, occasionally farmland.

Ochnaceae
O *Ouratea lucens* (Kunth) Engl.

Olacaceae
H O *Schoepfia schreberi* J.F.Gmel.
H O *Ximenia americana* L.

Opiliaceae
O *Agonandra obtusifolia* Standl.
O *Agonandra racemosa* (DC.) Standl.

Oxalidaceae
H **Averrhoa carambola* L.

Palmae
H O *Acrocomia mexicana* Karw. ex Mart.
H O *Cocos nucifera* L.

Papaveraceae
O *Bocconia arborea* S.Watson

Picramniaceae
H O *Alvaradoa amorphoides* Liebm.

Piperaceae
H *Piper amalago* L.
H *Piper marginatum* Jacq.

Polygonaceae
H *Coccoloba caracasana* Meisn.
O *Coccoloba liebmannii* Lindau
O *Coccoloba schiedeana* Lindau
H *Coccoloba venosa* L.
O *Podopterus cordifolius* Rose & Standl.
O *Podopterus mexicanus* Humb. & Bonpl.
O *Ruprechtia fusca* Fernald.
H O *Ruprechtia pallida* Standl.

Proteaceae
H *Roupala montana* Aubl.

Rhamnaceae
H *Colubrina arborescens* (Mill.) Sarg.
O *Gouania polygama* (Jacq.) Urb.
H O *Karwinskia calderonii* Standl.
O *Karwinskia humboldtiana* (Roem. & Schult.) Zucc.

Rubiaceae
H O *Alibertia edulis* (Rich.) A. Rich. ex DC.
H O *Calycophyllum candidissimun* (Vahl) DC.
O *Chiococca alba* (L.) Hitchc.
O ***Chiococca filipes*** Lundell
Category C (Oax Chis Hon – not limited to PDF). Seasonal oak forest.
H *Chomelia spinosa* Jacq.
H **Coffea arabica* L.
H *Coutarea hexandra* (Jacq.) K.Schum.
O *Exostema caribaeum* (Jacq.) Roem. & Schult.
H *Exostema mexicanum* A.Gray
H O *Genipa americana* L.
H ***Guettarda deamii*** Standl.
Category B (Guat ELS Hon Nic). Disturbed forest fragments.
O *Guettarda elliptica* Sw.
O ***Guettarda galeottii*** Standl.
Category B (Sin Nay Oax). Fallows.
H *Hamelia patens* Jacq.
O *Hamelia versicolor* A.Gray
O *Hintonia latiflora* (Sessé & Moc. ex DC.) Bullock
H *Palicourea crocea* (Sw.) Roem. & Schult.
O *Psychotria horizontalis* Sw.
H O *Psychotria microdon* (DC.) Urb.
H O *Psychotria pubescens* Sw.
O *Psychotria tenuifolia* Sw.
O *Randia aculeata* L.
O *Randia armata* (Sw.) DC.
O ***Randia cinerea*** (Fernald) Standl.
Category B (Oax Gro). Fallows.
H *Randia cookii* Standl.
H *Randia echinocarpa* Moc. & Sessé ex DC.
O *Randia laevigata* Standl.
O *Randia malacocarpa* Standl.
O ***Randia nelsonii*** Greenm.
Category C (Sin Mich Oax Ver – not limited to PDF). Mature forest fragments.
H ***Randia pleiomeris*** Standl.
Category C (Guat ELS Hon – not limited to PDF). Disturbed forest fragments and farmland.
O *Randia tetracantha* (Cav.) DC.
O *Randia thurberi* S.Watson
H O ***Rondeletia deamii*** (Donn.Sm) Standl.
Category C (Oax Guat Hon Nic – not limited to PDF). Forest fragments and farmland.
O *Rondeletia leucophylla* Kunth

Rutaceae
O *Amyris balsamifera* L.
H O **Citrus aurantifolia* (Christm.) Swingle
H **Citrus aurantium* L.
H **Citrus limeta* Risso
H **Citrus paradisi* Macfad.
H **Citrus reticulata* Blanco
H O **Citrus sinensis* Osbeck
H O *Esenbeckia berlandieri* Baill. ex Hemsl. ssp. *litoralis* (Donn.Sm.) Kaastra
O **Murraya paniculata* (L.) Jack
O *Zanthoxylum affine* Kunth
H *Zanthoxylum anodynum* Ant. Molina
O *Zanthoxylum arborescens* Rose
H *Zanthoxylum culantrillo* Kunth
O *Zanthoxylum fagara* (L.) Sarg.
H *Zanthoxylum microcarpum* Griseb.

Salicaceae
O *Salix bonplandiana* Kunth

Sapindaceae
H *Allophylus psilospermus* Radlk.
H *Allophylus racemosus* Sw.
O *Cupania dentata* DC.
H *Cupania glabra* Sw.
H *Cupania guatemalensis* Radlk.
O *Dodonaea viscosa* Jacq.
H *Melicoccus bijugatus* Jacq.
H O *Sapindus saponaria* L.
H O *Thouinia serrata* Radlk.
O *Thouinia villosa* DC.
H O *Thouinidium decandrum* (Humb. & Bonpl.) Radlk.

Sapotaceae
H *Chrysophyllum cainito* L.
O *Chrysophyllum mexicanum* Brandegee ex Standl.
H *Pouteria campechiana* (Kunth) Baehni
H *Pouteria sapota* (Jacq.) Moore & Stearn
H O *Sideroxylon capiri* (A.DC.) Pittier ssp. *tempisque* (Pittier) T.D.Penn.
O *Sideroxylon cartilagineum* (Cronquist) T.D.Penn.
O *Sideroxylon celastrinum* (Kunth) T.D.Penn.
H O *Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn.

Simaroubaceae
O ***Castela retusa*** Liebm.
Category A. Mature forest fragments.
H O *Quassia simarouba* L.f. (=*Simarouba glauca* DC.)
O ***Recchia mexicana*** Moc. & Sessé ex DC.
Category B (Oax Jal). Mature forest fragments, occasional fallows.

Solanaceae
H *Cestrum dumetorum* Schltdl.
O *Juanulloa mexicana* (Schltdl.) Miers
H *Solanum americanum* Mill.
H *Solanum erianthum* D.Don
H *Solanum hazenii* Britton
H *Solanum hirtum* Vahl
H *Solanum torvum* Sw.
H *Solanum verbascifolium* L.

Staphylaceae
H *Turpinia occidentalis* (Sw.) G.Don.

Sterculiaceae
H *Ayenia micrantha* Standl.
O *Ayenia palmeri* S.Watson
H O *Guazuma ulmifolia* Lam.
O *Helicteres mexicana* Kunth
O *Melochia glandulifera* Standl.
H O *Melochia nodiflora* Sw.
O *Melochia tomentosa* L.
O ***Physodium oaxacanum*** Dorr & Barnett[3]
Category B (Oax Chis).
H *Sterculia apetala* (Jacq.) H.Karst.
H *Theobroma cacao* L.
O ***Waltheria conzatii*** Standl.
Category A. Fallow.
H O *Waltheria indica* L.

Theophrastaceae
H O *Jacquinia macrocarpa* Cav.

O ***Jacquinia seleriana* Urb. & Loes.**
Category A

Tiliaceae
H *Apeiba tibourbou* Aubl.
O *Heliocarpus donnell-smithii* Rose
O *Heliocarpus mexicanus* (Turcz.) Sprague
O ***Heliocarpus occidentalis*** Rose
Category C (Sin Jal Nay Col Gro Oax). Mature forest fragments.
O *Heliocarpus pallidus* Rose
H O *Luehea candida* (Moc. & Sessé ex DC.) M.Mart.
H *Luehea speciosa* Willd.
O *Muntingia calabura* L.
O *Trichospermum mexicanum* (DC.) Baill.
H O *Triumfetta bogotensis* DC.
H *Triumfetta calderoni* Standl.
O *Triumfetta dumetorum* Schltdl.
O ***Triumfetta heliocarpoides*** Bullock
Category B (Gro, Oax) Seasonal oak forest.
O *Triumfetta paniculata* Hook. & Arn.

Trigoniaceae
H ***Trigonia rugosa*** Benth.
Category C (Guat ELS Hon Nic – not limited to PDF) Disturbed forest fragments.

Turneraceae
O *Turnera ulmifolia* L.

Ulmaceae
H O *Celtis iguanaea* (Jacq.) Sarg.
H O *Trema micrantha* (L.) Blume

Urticaceae
H *Myriocarpa bifurcata* Liebm.
H *Myriocarpa longipes* Liebm.
O *Urera baccifera* (L.) Gaudich ex Wedd.
O *Urera caracasana* (Jacq.) Griseb.

Verbenaceae
see also Labiatae
O ***Aloysia chiapensis*** Moldenke
Category B (Oax Chis). Solar.
O *Lantana camara* L.
H *Lantana urticifolia* Mill.
O *Lantana velutina* M.Martens & Galeotti
H *Lippia alba* (Mill.) N.E.Br.
H *Lippia cardiostegia* Benth.
O *Lippia umbellata* Cav.
H *Rehdera trinervis* (S.F.Blake) Moldenke

Violaceae
O *Hybanthus mexicanus* Ging.

Zamiaceae
O *Dioon edule* Lindl. var. *sonorense* (De Luca, Sabato & Vázq. Torres) McVaugh & Pérez de la Rosa

Zygophyllaceae
O *Guaiacum coulteri* A.Gray
H ***Guaiacum sanctum*** L.
Endangered. Disturbed forest fragments.

Notes
[1] Odontonema = Justica: Mabberley 1997
[2] Hybosema = Gliricidia (Mabberley 1997)
[3] Physodium = Melochia (Mabbberley 1997)

Appendix 5: Guide to key institutions

In this Appendix we provide a summary, which is not necessarily definitive, of the principal institutions and organizations which participated in the research and/or are of potential importance for the implementation of conservation strategies in the MTDF.

Oaxaca

- Centro de Soporte Ecológico (Ecological Support Centre). Bahía de Santa Cruz 119, Sector T, La Crucecita, Bahías de Huatulco, Oaxaca, México. Tel: (958) 70405. CSE is based on the Oaxacan coast, and promotes conservation and rural development activities in a number of catchments in and around the Huatulco area, such as reforestation and the promotion of sustainable forest management. One of the communities where CSE works is the CUBOS study community Santa María Petatengo.
- Centro Interdisciplinario de Investigación para el Desarrollo Rural (Interdisciplinary Centre for Research in Rural Development) - CIIDIR. Calle Hornos s/n Indeco c.p. 71230 Xoxocotlán, Oaxaca, México. Tel: (951) 70400. Email: cidiroax@vmredi.ipn.mx. CIIDIR is a research centre, which sponsors and carries out research and rural development activities in a number of communities in Oaxaca, including the CUBOS study community Santa María Petatengo.
- Comisión Oaxaqueña de Defensa Ecológica (Oaxacan Comisión for Ecological Defence) - CODE. Pino Suárez 901-2 c.p. 68000 Oaxaca, Oaxaca, México. Tel. (951) 38212. Email: code@infosel.net.mx. CODE is an umbrella organization of NGOs involved in conservation in Oaxaca.
- Grupo Autónomo de Investigaciones Ambientales, A.C. (Autonomous Environmental Research Group) - Calle Crespo 520-A, Centro Oaxaca, Oaxaca CP 68000, México Tel. (951) 5147528. Email: gaia@spersaoaxaca. GAIA has offices in both Oaxaca city and Santa María Huatulco, on the coast. It works in community-based rural development and conservation in communities in Santa María Huatulco municipality and surrounding areas, and has also been involved in the recent established Huatulco National Park.
- Grupo Mesófilo (Mesophyllous Group). Pino Suárez 205 c.p. 68000, Oaxaca, Oaxaca, México. Tel.: (951) 62835. Email: mesofilo@oax1.telmex.net.mx. An NGO which works principally in the Sierra Madre area of Oaxaca, but has carried out occasional activities related to the dry forest, including the preparation for CUBOS of a study of the policy context related to dry forest conservation.
- Instituto Estatal de Ecología de Oaxaca (Oaxaca State Ecology Institute) - IEEO. Libres 511-A c.p. 68000, Oaxaca, Oaxaca, México. Tel.: (951) 33288. Email: ecologiaoax@oaxaca.mx. The State level ecological institute in Oaxaca, which promotes initiatives of the State government in relation to conservation and environmental protection.
- Secretaría del Medio Ambiente, Recursos Naturales y Tierras (Environment, Natural Resources and Lanas Secretariat) - SEMARNAT. Sabinos 402, Col. Reforma c.p. 68050, Oaxaca, Oaxaca, México. The Oaxaca office of the Federal entity charged with environmental protection and the planning and regulation of natural resource use.
- Sociedad para el Estudio de los Recursos Bióticos de Oaxaca, A.C. (Society for the Study of the Biotic Resources of Oaxaca) - SERBO. Carretera Internacional KM 7 No. 22, San Sebastian Tutla, Oaxaca. c.p.71246, México. Tel.: (951) 5032100. Email:

serbo@antequera.com. An NGO which has carried out a large number of scientific studies throughout Oaxaca, including in the central dry forest area of the coastal region. It has good GIS and botanical capacity.

- WWF Regional Office/Oaxaca Programme. Jazmines 217, Col. Reforma, 68050 Oaxaca, Oaxaca, México. Tels: (951) 36723/36729. Email:wwfoax@antequera.com. WWF has for a number of years worked in coordinating conservation activities in Oaxaca, and has acted as an important channel of funds to local NGOs.

Honduras

- Instituto de Conservación y Desarrollo Forestal (Institute for Forest Conservation and Development) – ICF. Tel.: (504) 223 4346. The Government agency (a dependency of the Ministry of the Presidency) which, under the new Forestry Law (approved by Congress in 2007), took over from AFE-COHDEFOR in 2008 as the forestry authority responsible for regulating tree and forest use.
- Asociación Sureña para la Conservación de la Naturaleza (Southern Association for Nature Conservation) - ASCONA. Centro San José Obrero, Choluteca. A local organization which has carried out small-scale conservation activities including tree planting and environmental education.
- CARE Honduras. Avenida República de Costa Rica, Sub. Lomas de Mayab, Tegucigalpa, Honduras. Tel.: (504) 239 4425. http://www.care.org. One of the largest development NGOs in southern Honduras, whose projects have included a water supply and conservation programme for communities around Cerro Guanacaure, one of the largest forest remnant in the area.
- Comisión para la Defensa de la Fauna y Flora del Golfo de Fonseca (Comisión for the Defence of the Fauna and Flora of the Gulf of Fonseca) - CODDEFFAGOLF. http://www.coddeffagolf.org. Apdo. Postal 3663 Tegucigalpa. Tel./Fax (504) 238-0415. An environmental NGO and pressure group which carries out conservation and rural development activities, such as reforestation aimed at reducing the pressure on the mangroves of the Gulf of Fonseca Ramsar site.
- Conservación de los Recursos Forestales de Honduras (Forest Resource Conservation Project) - CONSEFORH. Email: consefor@hondutel.hn. A project of AFE-COHDEFOR, established with support from ODA/DFID, which has carried out extensive genetic explorations, seed collections and on-station trials, seed orchards and ex situ conservation plantings with dry forest species.
- Programa para la Conservación y el Desarrollo del Medio Ambiente (Environmental Conservation and Development Programme) - PROCONDEMA. Tel.: (504) 882 0028. An NGO linked to the Catholic Church which works in rural development and natural resource conservation, including the promotion of sustainable organic hillside agriculture and local community-based environmental protection committees.
- Programa Nacional para el Desarrollo Rural Sostenible (National Programme for Sustainable Rural Development) – PRONADERS. http://www.pronaders.hn. The programme implemented by the SAG (through the National Direction of Sustainable Rural Development DINADERS) responsible for promoting sustainable rural development, through projects largely funded by international agencies.

- Secretaría de Agricultura y Ganadería (Agriculture and Livestock Secretariat). Tel.: 235 6730. http://www.sag.gob.hn. The Government Ministry with responsibility for agriculture and livestock and rural development.
- Secretaría de Recursos Naturales y Ambiente (Natural Resources and Environment Secretariat). Tel.: 239 1918. http://www.serna.gob.hn. The Government ministry with responsibility for formulating environment and natural resources policy and for regulating biodiversity use. The national focal point for GEF, CBD and CITES.
- Visión Mundial (World Vision). Apartado Postal 3204, Tegucigalpa. Tel.: 236 7024 (Tegucigalpa office). http://www.worldvision.org. An NGO working in rural development in a number of communities in the south.

Regional Institutions

- Centro Agronómico Tropical de Investigación y Enseñanza (CATIE). CATIE 7170, Turrialba, Costa Rica. Tel.: (506) 556 7830. http://www.catie.ac.cr. The largest research and teaching centre in the region, based in Costa Rica, particularly active in the areas of agroforestry and forest management.
- Comisión Centroamericana para el Ambiente y el Desarrollo (Central American Comisión for Environment and Development) - CCAD. Blvd. Orden de Malta No. 470, Urbanización Santa Helena, Antiguo Cuscatlán, El Salvador. Tel.: (503) 289 - 6131, Fax: (503) 289 - 6126/27. http://ccad.sgsica.org/. Regional inter-governmental commission aimed at promoting environmental protection and sustainable development. Implementing agency for the regional plans of the Mesoamerican Biological Corridor.
- Corredor Biológico Mesoamericano (Mesoamerican Biological Corridor). Email: cbm@undp.org. Regional initiative aimed at promoting connectivity throughout Mesoamerica. Currently a project supported by UNDP, GEF, GTZ and CCAD is underway aimed at consolidating the Corridor.

Annex 6: Suggested reading

Conservation through use

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This book examines the concept of 'conservation through use', using the conservation of tree species diversity in Mesoamerican tropical dry forest in Honduras and Mexico as a case study. It discusses the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods. Based on a detailed analysis of smallholder farming systems in southern Honduras and coastal Oaxaca and a botanical survey of trees and shrubs in different land use systems in both study areas, the findings confirm the importance of involving the local population in the management and conservation of Mesoamerican tropical dry forest.

The book is directed at researchers in both the socioeconomic and botanical spheres, policy makers at both national and international level, and members of governmental and non-governmental organisations, institutions and projects active in the conservation of tropical dry forest and in rural development in the region.

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Methods in Development Research:

Combining Qualitative and Quantitative Approaches

Edited by
JEREMY HOLLAND
with
JOHN CAMPBELL

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The third conclusion is that the most relevant question here is not a methodological one, but has to do with the combination of politics, policy and techniques within development research. In this sense, the distinction between contextual and non-contextual approaches appears to be a much more promising horizon for research than the rather technical discussion on the quantitative–qualitative divide. In contextual approaches and methods, the main interest is understanding of the relationship existing among different individuals and groups, their social, cultural, natural and economic environments, and the processes of self-organization that take place through the dynamic changes affecting the system (where a system is any social process made by structures and relations). In contrast, non-contextual approaches and methods are more concerned with the determination of the behaviour of a set of variables than with the systemic relationships existing among those and other aspects of reality.

It is worrying, then, that the question of how contextual and non-contextual approaches relate to particular ideological–epistemological perspectives has so far been overlooked within development research. Practitioners must ask themselves how different world views are reflected in the practice of planning and evaluation and how these visions of reality determine the politicized use of qualitative and quantitative methods.

Chapter Thirteen
Trade-offs between management costs and research benefits: lessons from the forest and the farm[1]

KATHRIN SCHRECKENBERG, ADRIAN BARRANCE, ANN DEGRANDE, JAMIE GORDON, ROGER LEAKEY, ELAINE MARSHALL, ADRIAN NEWTON and ZAC TCHOUNDJEU

Summary

Projects aspiring to combine qualitative and quantitative research methods face the challenge of achieving the integration of different research methods and their results without compromising the quality of component parts. In the natural resource field, the seasonal imperatives of botanical and biophysical research can restrict flexibility of 'process' projects subject to the sometimes less predictable pace of participatory socio-economic methods. Another difficult issue relates to how to combine methods which operate at different scales. A third arises from the fact that many researchers specialize in either qualitative or quantitative research. Combining the two therefore often implies a collaborative effort between researchers from different disciplines and organizations. This chapter draws on experience from three multi-disciplinary and multi-institutional development research projects (dealing with conservation of trees on farms in Honduras and Mexico; domestication of indigenous fruit trees in Cameroon and Nigeria; and commercialization of non-timber forest products in Bolivia and Mexico) and a PhD study (on supply and demand of non-timber forest products in Benin) to highlight some key lessons. These include the value of jointly developed hypotheses as integrating factors, and the need for intensive management, reciprocal training of researchers and frequent joint reviews including interim data-analysis workshops. In exchange for often very high management costs, the rewards for successful projects are a set of conclusions that are greater than the sum of the separate parts.

Introduction

This chapter looks at some of the institutional challenges in combining qualitative and quantitative approaches in development research, and asks whether the benefits outweigh the costs. We focus on experience from the forestry (including agroforestry) sector, specifically from the conservation/development interface where debate is often polarized along quantitative and qualitative lines, respectively. Our basic premise, however, is that questions relating to the complex interactions of people and natural resources can be answered only by drawing on

some combination of quantitative and qualitative information. We also assume that this should be done without compromising the quality of data collection for any component approach. Finally, we take it as read that, in the specific context of development research, there is usually a strong emphasis on partners' capacity-building and achieving buy-in of the eventual users of the research results.

To examine the reasons why the reality of achieving these goals is often frustrating, we draw on four different development research projects, all of which deal loosely with the use by local people of trees in a more or less managed environment: supply and demand of non-timber forest products (NTFPs) in Benin; conservation of trees on farms in Honduras and Mexico; domestication of indigenous fruit trees in Cameroon and Nigeria; and commercialization of NTFPs in Bolivia and Mexico. Each involved different numbers and types of researchers and institutions, as well as representing a different combination of research approaches (see Table 13.1 overleaf). Based on the experiences of these projects, we highlight some of the key practical challenges and trade-offs (in terms of resources and time) associated with trying to bring together more qualitative and quantitative approaches.

Obstacles to integration

A similar range of problems was encountered in all four projects. Some related specifically to how to combine more qualitative and quantitative approaches in the field; some were more to do with the different worldviews of researchers working in different disciplines; and others arose from the fact that collaborating across different disciplines almost always means collaboration across institutions.

Getting the sequencing right

As outlined by Holland and Campbell (see General Introduction), the key to the effective combination of methods and data lies in the iterative relationship between descriptive (usually more quantitative) and explanatory (more qualitative) approaches. In practice, this means careful and, where necessary, flexible sequencing of methods so that the results of one strand can feed into another.

Sequencing of methods in the natural resource field is complicated by the fact that so many of them – whether qualitative or quantitative – are seasonally constrained. Phenological studies are by their very nature a record of change across the seasons. Yield studies or market surveys for fresh produce (fruit, leaves, etc.) are similarly seasonal, and farmers are more 'switched on' to discussion of domestication issues when the trees are fruiting. Botanical surveys may be restricted to the times of year when plants are in leaf but the terrain remains accessible. In the same way, much community-level and household-level work is dependent on farmer availability – affected by both seasonal migration and the agricultural calendar as well as daily work patterns.

Seasonality issues can spoil plans for integration. In the 'Conservation through use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS) project in Honduras, for example, our initial aim had been to have a combined fieldwork team consisting of a socio-economist and a botanist to carry out semi-structured household interviews and biodiversity inventories of the household's plots, the latter accompanied by a member of the household being interviewed. The botanical surveys were under great seasonal constraints, however, and were found to be so time-consuming that it was impossible to wait for farmers' availability to do them. We were therefore obliged to separate the socio-economic and botanical teams.

The CUBOS project also illustrates the importance of being clear about the objectives of a project when deciding how to sequence methods. If CUBOS had been only about finding the most effective way to conserve threatened tree species diversity, then we should have focused first on botanical surveys to determine the location of threatened species (which turned out to be only in Mexico and not in our other case-study country, Honduras), and then carried out the socio-economic research to see how to conserve them. The fact that the project also had livelihood objectives, however, justified the concurrent implementation of both qualitative and quantitative methods.

Sequencing can also be constrained by how experienced researchers are in different methods. The researcher's knowledge of an area is more important in determining the quality of qualitative than quantitative work (Schreckenberg 1995). In Benin, for example, the same participatory research was carried out with five groups of women one after the other, over a period of nine months. The information collected later was much more complete and reliable than that obtained from the first group of women. In the early stages we accepted too much information at face value. Later, with a deeper understanding of the area (in part derived from collecting a range of quantitative data on natural resources and markets), we were better able to recognize evasive statements or conflicting information, and to probe further. A research team new to an area may, therefore, be better off starting with quantitative work and only engaging in qualitative work at a later stage.

The greatest difficulties arise when trying to combine seasonally constrained methods with a 'process' approach in which the issues raised in early rounds of research determine the direction taken by later research activities. In the project 'Commercialisation of Non-timber Forest Products in Mexico and Bolivia: Factors Influencing Success' (CEPFOR), the main data collection tool – a questionnaire investigating various aspects of the commercialization process of NTFPs among community members and traders – was developed in a very participatory manner and took into account the results of preliminary qualitative work in the study communities. By the time it had been completed, tested and revised, however, the pressure to implement it quickly was very great if the project was to finish on time. Unfortunately, of the ten NTFPs studied several were highly seasonal, and some of the commu-

Table 13.1 *Comparison of methodological aspects of four projects*

	Benin PhD	**CUBOS**	**Cameroon project**	**CEPFOR**
Project aims	Investigate demand and supply of non-timber forest products (NTFPs) in the Bassila region of Benin	Investigate the potential for conservation-through-use of trees on-farm in the Mesoamerican dry forest zone of southern Mexico and Honduras	Investigate the constraints and opportunities for resource-poor farmers to obtain greater benefits from indigenous fruit trees	Investigate the factors that determine the success or failure of commercialization enterprises
Countries of fieldwork	Benin	Mexico, Honduras	Cameroon, Nigeria	Mexico, Bolivia
Countries of partners	Germany, UK	UK	UK, Australia	UK, Nicaragua
Languages	English, French	English, Spanish	English, French	English, Spanish
Number of partners, organization type	2 universities. 1 bilateral forestry project	1 university. 1 research institute. 4 herbaria. 2 government departments. 1 international and 2 national NGOs. 3 independent researchers	2 research institutes. 2 CGIAR organizations. 1 commercial research institute. 1 national agricultural research institute. 1 government extension service. 4 national NGOs, 1 bilateral project	2 research institutes 2 international and 3 national NGOs. 2 independent researchers
Core research team with disciplines*	1 person (social forestry)	5 people (social forestry x 2, forestry, natural resource economics, botany)	5 people (social forestry, agroforestry x 2, agricultural economics, market economics)	6 people (natural resource management, ecology, social forestry, market economics x 2, econometrics)
Time frame	1992–6 (13 months)	1996–2003 (4 years)	1999–2003 (2.5 years)	2001–4 (4 years)
Reference	Schreckenberg (1996)	Gordon et al. (2003)	Leakey et al. (2003)	Marshall et al. (2003)

* 'Core' team members are those who contributed substantially to the development of the research methods and analysis of the results. 'Other' team members are those who participated in the implementation of the research.

	Benin PhD	**CUBOS**	**Cameroon project**	**CEPFOR**
Methods used, listed in order of those producing the most quantitative data through to those producing the most qualitative data	Tree inventory around 3 villages to measure density of NTFP species. Fortnightly phenological study of 11 NTFP species. Yield studies for 2 species. Weekly market surveys at 2 markets. Household surveys of NTFP use in 4 villages. Focus groups on women's income and expenditure patterns. Focus groups on uses of main NTFP species. Participant observation of NTFP harvesting and processing	Botanical surveys of species occurrence in different land-use types in 8 communities. Economic studies of benefits of on-farm trees in 2 communities. Community-level participatory work in 8 communities. Semi-structured household interviews in 8 communities on tree management and use practices. Focus groups on particular tree products and production systems	Biophysical measurements of fruit of 2 species. Phenological studies of same 2 species. Monthly NTFP market surveys at 11 markets. Inventories of fruit trees on farms in 6 communities. Community-level participatory work. Household interviews in 6 communities	Household surveys in all 17. communities. Trader surveys along market chains for 10 NTFPs. Market reports for 10 NTFPs. Community-level participatory work in 17 communities. Background policy study in each country
Sequencing of methods	Phenological study and market surveys carried out simultaneously with focus groups. These provided background for development of a very specific household survey instrument applied at end of study period. Timing of inventory and yield studies determined by seasonality	Community-level work provided general context for selection of households for household interviews. Timing of botanical surveys constrained by seasonality and need for land-use information from the household interviews. Results from household interviews and botanical surveys fed into design of economic study. Information from household interviews later cross-checked with focus groups	Community-level work provided context for selection of households for interviews and farm inventories. Biophysical and phenological work constrained by seasonality. Market surveys carried out independently of other work but in nearest markets to study communities	Community-level work provided context for selection of households for surveys and for identifying market routes and traders to be interviewed. Together with policy studies, community-level work helped identify the issues to be addressed in the household survey
Existence of explicit research themes	No. Methods used to explore general research hypotheses	No. Some implicit in project document but never explicitly amended in the light of emerging findings and changing donor priorities	No. But some developed as research progressed	Yes. 6 hypotheses, each with about 10 research questions, were developed at first project meeting
Number and types of meetings held	None between all partners. Few others. Most consultation by post	All project partners only brought together for final project 'maturity' meeting. Core team met about once a year	Inception workshop with training of whole team. Interim monitoring workshop. Data analysis workshop. Maturity workshop. Writing workshop. UK-based team met twice a year	4 workshops for core team. 2 inception workshops in Bolivia and Mexico. 2 market training workshops. 2 whole project data analysis workshops. 1 dissemination workshop. Quarterly meetings of UK-based team
Reference	Schreckenberg (1996)	Gordon et al. (2003)	Leakey et al. (2003)	Marshall et al. (2003)

nities were accessible for only part of the year. Implementation of the questionnaire in some communities was therefore substantially delayed, with knock-on effects on the timing of data analysis.

This raises the issue of how to squeeze research, of whatever type, into a conventional project cycle. Even a slight delay in starting a project can lead to the boat being missed on some seasonally constrained activities and, in turn, require a change in the overall sequence of methods. Sequencing is further complicated by the need for development research projects to keep an eye on the policy process, producing briefings for specific events. Donors' requirements for interim policy outputs also put increasing pressure on interdisciplinary research projects, which may need to draw on several strands of research (each with its own timetable of analysis) to come up with integrated recommendations.

Reconciling sampling strategies

Sampling strategies (and the resulting recommendation domains) are without doubt one of the most difficult issues to resolve within a multidisciplinary team. The first issue relates to sampling over time. Many quantitative approaches in the forestry sector are dependent on the vagaries of nature (e.g. phenological, yield and market studies) and should be carried out over several years to enable the team to learn (test and amend methods) in the first season, and to allow for year-to-year variation in fruiting (which may impact on prices etc.). In the Cameroon project, for instance, many of the trees that had been selected for observation did not fruit in the year we were working. This need to carry out fieldwork over several years may be difficult to combine with qualitative approaches (community-level participatory reflection and action in the Cameroon case) that hope to provide rapid feedback to communities.

It may also be necessary to compromise over spatial sampling. In Cameroon the fact that the 'biophysical' team (who were measuring variation in fruit characteristics) needed to access trees of particular species meant that one of the four case-study villages was selected for its abundance of a particular species, even though it was not typical of the area in many socio-economic respects. Furthermore, although we wanted to carry out the biophysical work on the trees observed in the farm tree inventories, this was not possible because the biophysical study required a minimum number of trees and these could not be found within the 20 households involved in the farm inventory (and sometimes not even within the village selected). So the biophysical sampling strategy had to be adapted, and we were unable to test some of the hypotheses (e.g. that various farmer characteristics were linked to particular fruit characteristics) that would have required socio-economic and biophysical information to be collected for the same trees/owners.

Collaborating across disciplines

Modern researchers tend to undergo increasingly specialized disciplinary training. Bringing together qualitative and quantitative approaches therefore requires not just a multidisciplinary team, but also a multi-person one. This means that projects need to deal with the relative requirements of the methods as well as of individual researchers and their parent institutions.

Trying to meet several individual research agendas may 'inflate' projects beyond what is necessary to answer the central questions. How willing individuals are to compromise depends greatly on how well they understand, and are interested in, the different project components. This kind of mutual respect and common focus on project goals may take time to develop. In the CEPFOR project, for example, although the core team decided early on to take a participatory approach to developing the research methods, the implications of what this meant in practice were not explicitly discussed or agreed by all team members. As a result, the inception workshops in each country were primarily devoted to collecting a specific subset of data from participants to enable an early trial data analysis. But this meant that methodology development had to be pursued by email in a manner that was very time-consuming and did not result in immediate ownership of the overall approach by all partners.

Ideally, trust should be established when sampling strategies and data quality issues for each research strand are being discussed, as these issues can usually be understood across disciplines. Data analysis, however, may be beyond all but the relevant specialists. Having confidence in each other's conclusions therefore depends on the trust built up early on in the project.

One of the problems of a multidisciplinary team is that it is often large, and few researchers are likely to be working on the project full-time. Budget constraints simply make it impossible to fund a large number of specialists for the duration of the project. Instead, each one is paid for short periods, sufficient to carry out their research component, but rarely sufficient to cover the interaction time required to facilitate integration between disciplines. When all a project's researchers are dividing their time between several activities, it is difficult enough to schedule fieldwork, let alone cross-disciplinary project meetings. Successful integration of qualitative and quantitative approaches therefore almost inevitably extends the length of the project.

Collaborating across institutions

Given that many institutions specialize in a particular type of research, achieving multidisciplinarity often requires working with several institutions. This introduces many complications that, although only indirectly the result of combining qualitative and quantitative approaches, can prove a serious obstacle to integration.

All institutions have different ways of working, including the extent to which they insist on strategic versus operational planning of research agendas. In some cases research must be included in annual work plans, in others it can be planned more quickly and informally. Differing financial years can complicate budget management, as can varying flexibility in an institution's ability to transfer funds between years and budget lines. Together these factors determine how likely an organisation is to be able to support a process project in which qualitative and quantitative approaches are sequenced in response to results of earlier data collection.

Different institutions typically have quite different goals, which can impact greatly not only on how research is carried out, but also on what forms of dissemination are expected. Thus academic institutions are interested in testing research hypotheses, and researchers are judged on the basis of peer-reviewed publications. Others are more interested in achieving policy impact. Development NGOs, on the other hand, usually want immediate results for the study communities. The Benin PhD study was a typical example of the problem of having multiple taskmasters – the university required 'innovative' work; the bilateral donor required standardized data; and the host project sought practical advice – resulting in the need to collect sufficient data to satisfy all three and produce several types of output. In such a situation, it is essential that all stakeholders agree exactly who needs what at an early stage.

Three of the projects worked with local NGOs, most of which had either a strongly qualitative development focus, or a more quantitative conservation focus. While this caused some difficulties with respect to how receptive they were to multidisciplinary approaches, a more fundamental issue was their lack of experience in carrying out rigorous research. In the CEPFOR project, it became clear that this was particularly problematic for qualitative data collection. We had selected various participatory reflection and action tools precisely because our NGO partners were experienced in using them, but it turned out to be impossible to convince partners that these needed to be employed as rigorously as our quantitative data collection tools if we wanted data that were comparable across the 17 study communities.

The Cameroon project represents an ideal case in which the national coordinating organization, in this case the World Agroforestry Centre (ICRAF), itself has a mandate to work in an interdisciplinary manner and therefore had a good understanding of the methodological and consequent logistical needs of all the research strands.

Making it work: the costs

Over the course of the four projects it has become clear that compromise and sufficient resources of time and money can help overcome many of the obstacles discussed above.

Joint development of hypotheses

Jointly developed hypotheses can be an excellent way of focusing all project partners on the key thematic questions. They are particularly useful in determining the relative contributions of qualitative and quantitative approaches, and how they can be integrated most effectively.

It pays to state hypotheses explicitly, unlike in the CUBOS project in which hypotheses resided primarily in the heads of the original project planners. They were therefore not 'owned' by the new field team that took over just after the inception of the project. As a result, for justifiable logistical and methodological reasons, this team dropped some of the more quantitative elements of the household interviews and botanical surveys. Some of the analysis originally foreseen was therefore not possible. The lack of guiding hypotheses was compounded by low-intensity management (split between two institutions with very different worldviews), and a lack of project reviews which might have enabled the team to identify and remedy data gaps at an early stage.

The CEPFOR project took the decision to invest time in developing six fairly general hypotheses, each supported by a set of more specific research questions. Based heavily on the international literature, these turned out to be an excellent way of introducing national partners to this body of theory. More importantly, they were an essential tool for ensuring that different components of the research focused on the same issues and fed into each other's analysis (see Table 13.2, page 201).

Many research projects compromise on their methodology to keep within budget and time. The existence of a clear set of hypotheses can be very helpful in determining just how much it is possible to compromise before the project loses its focus. In the CEPFOR project, for example, it was impossible to carry out a detailed quantitative market analysis for all the NTFPs studied, and decisions about which to drop were based on how much each product could contribute to the understanding of the project's hypotheses. This also illustrates that it is often not necessary for all research methods to be implemented across all case-study products or communities. The Cameroon project found that it was more effective to focus qualitative community-level work in Cameroon only, while some of the more quantitative tools were also used in two Nigerian communities. Although less complete, the Nigerian data provided a good balance to the Cameroon data and greatly enriched the overall results.

Reciprocal capacity-building

Ravallion (2003) argues that the main barriers to mixing qualitative and quantitative methods lie in the resistance of practitioners to stepping outside the traditional boundaries of practice. To get around this, both the Cameroon and CEPFOR projects invested heavily in capacity-building for their partners.

The Cameroon project began by training biophysical, market and socio-economic researchers in participatory methods and community-

level work. In addition to generating a broad understanding of the aims of the project, the training course was a fun way for the diverse research team to get to know each other and appreciate each other's skills and disciplinary perspectives. At the time, we considered it less important to train the whole team in the more quantitative (and seemingly more straightforward) biophysical and market research techniques. In retrospect this was a missed opportunity for the biophysical team, in particular, to influence elements of the market and socio-economic work.

In addition to providing cross-disciplinary training, the CEPFOR project illustrated the need to train NGO partners in general research best practice, including consistent standards of data collection, recording and management. It also showed that ongoing capacity-building was vital not just for the field staff, but also for the core planning team to ensure that they understood and respected each other's approaches. This was achieved through frequent team meetings and mini-seminars by each specialist, enabling participants to begin to understand each other's disciplinary languages and appreciate both the potential and the limitations of different analytical approaches.

Early joint analysis

Meetings to trial analysis at an early stage of the project are an essential part of capacity-building for partners, who are much more likely to collect data well if they understand how they are going to be used. Such meetings also provide an early opportunity to determine whether data type and quality are sufficient to meet the project's needs. In Cameroon, for example, very simple information such as 'plot age' was not recorded on the inventory forms, as the collectors did not realize the importance of this particular information for linking different data sets. Delays between data collection and analysis meant it was then impossible to go back to the same plots to complete the data.

In the CEPFOR case, conclusions based on early analysis of the quantitative data were challenged by the qualitative information, and further inspection revealed an error in the original data. Parallel analysis of the different strands also highlighted which of the project's hypotheses and research questions were not being sufficiently tackled by any strand.

Joint analysis at an early stage of the project has the added advantages of focusing the minds of the mainly part-time research team; providing a deadline for work components to be completed by; and, where necessary, helping to bring the different research strands back into step with one another.

Inviting selected disciplinary experts to some of these analysis meetings can be very rewarding. In the CEPFOR project, for example, an external statistician facilitated an important discussion about the limitations of our varied research approaches and the implications for the project's recommendation domains.

Table 13.2 *How the CEPFOR project used hypotheses and research questions to determine data source and type of analysis*

Hypotheses and research questions	**Data source**	**Analysis methods**	**Who?**
Hypothesis: changes in trade in non-timber forest products (NTFPs) have a greater impact on the poorest producers, processors and traders			
Research question: are the same individuals involved in production (collection and cultivation), processing and trade?	1. Survey question 1.1 2. Community reports sections 7.5 and 7.6	1. Regression against measures of success 2. Tabulation by products and communities	1. DWtV 2. EM and KS
Explanatory note: Each of the project's six hypotheses was broken down into several research questions	Explanatory note: For each research question we determined which data sources would provide relevant data	Explanatory note: This column indicated what kind of analysis would be carried out	Explanatory note: Here we assigned responsibility for different parts of the analysis

Intensive management, frequent reviews and long-term commitment

A full-time research coordinator is always a benefit, but particularly so in multidisciplinary (and multi-institutional) projects which require additional work to ensure that all collaborators work towards the same goal. It is important that this person understands the research requirements of all partners and can mediate fairly between different research strands as necessary, for example if compromises on sampling strategies are needed, or delays in one component cause problems in another. In a comparative project, at least one person from each discipline should know most, if not all, the fieldwork sites in order to be able to evaluate the quality of the data collected in them.

It is almost impossible for a project crossing disciplinary, institutional, and usually national boundaries to have too many opportunities to feed ideas from one research team/component to the other(s). As much as email has revolutionized communications, crossing disciplinary boundaries requires a great deal of trust between collaborators which can best be fostered through frequent face-to-face meetings. In the CEPFOR project meetings built rapport and enabled all collaborators to question, doubt and explore issues directly with other partners – fuelling learning curves, increasing transparency, and reducing any

potential confusion, misunderstanding or resentment in achieving joint project goals.

In addition to the more intensive management required and greater number of cross-project meetings, a project combining qualitative and quantitative approaches is likely to need more time simply to allow for the complexity of sequencing, particularly if seasonally constrained quantitative methods are being integrated into a process project.

The rewards

Carvalho and White (1997) discuss three ways of combining the best of qualitative and quantitative approaches:

- **integrating** the quantitative and qualitative methodologies
- **examining, explaining, confirming, refuting and/or enriching** information from one approach with that from the other
- **merging the findings** from the two approaches into one set of policy recommendations.

Each of the four case-study projects attempted to achieve some or all of these in different measure. The Benin PhD study deliberately kept each methodological approach quite separate to avoid compromising quality. The fact that all were undertaken by a single researcher, who could determine sequencing to suit the needs of the research rather than being constrained by the availability of disciplinary specialists, meant that the separate methods were used in a flexible and iterative manner. As a result, even though the research was carried out during a single year, a combination of information about agricultural practices, how women earned their livelihoods, and patterns of tree densities (from tree surveys) allowed for a complex understanding of how NTFP use was changing over time.

The original aim of the CUBOS project was to integrate the botanical and socio-economic methodologies. In the event this was not practical, but the two teams at least overlapped in the same communities for some of the time and ended up providing different but complementary types of information. In comparing biodiversity in Honduras and Mexico, for example, a good grasp of tenure issues and their relation to biodiversity was vitally important to understand why some areas might have rare species and others not. By merging the findings from the two approaches, it was possible to derive rich policy recommendations that spoke to both conservation and livelihoods worlds.

In Cameroon, there was no direct integration of methodologies. although each took into account the other's needs when determining sampling strategies, and used the same villages. The location of the project within a permanent research institution with ongoing work in the study areas also made it possible for some iteration to take place and additional research to be carried out. The merging of the findings from the qualitative and quantitative strands was important not just in

the development of high-level policy recommendations, but also at a very practical level in helping farmers select trees for domestication. This requires not only an understanding of people's varied preferences (e.g. for large kernels or tasty fruit; for low trees to facilitate harvesting; or for aseasonal production to meet local market requirements), but also an understanding of the existing biophysical variation within a particular species or tree population, and how different characteristics are linked. For the individual researchers the greatest benefit of the multidisciplinary collaboration was the personal understanding and experience they gained, which has benefited their subsequent work.

The CEPFOR project made the greatest attempts to achieve methodological integration. Its research hypotheses were framed in such a way that they could have been investigated only with a combination of qualitative or quantitative approaches. Based on qualitative work at community level, the project developed a survey tool that provided data for econometricians, market analysts and socio-economists, and for use in the development of Bayesian belief networks. The process was much more time-consuming than if the research approaches had been pursued separately, and also led to some loss of quality in the data collected. The benefits were in the establishment of a truly inter-disciplinary team, from field-based researchers to office-based managers, who shared a fuller understanding of the project objectives and achievements, and in a comprehensive and multifaceted approach to commenting on the project's hypotheses.

Overall, the projects suggest that there are many benefits of combining qualitative and quantitative approaches:

- more complex understanding of the issues being researched leads to more meaningful and often more precise recommendations
- drawing on different disciplinary approaches ensures a broader policy impact as recommendations are taken seriously by policy makers from both quantitative and qualitative schools
- reciprocal capacity-building within the team opens researchers' eyes to the potentials and pitfalls of different approaches
- working within a multidisciplinary team means researchers are constantly being challenged to justify their approach and conclusions, ensuring that only the best is taken from each
- the continuing challenge and opportunity to learn from colleagues leads to much greater researcher satisfaction.

Conclusions: is it worth it?

This chapter began with the premise that natural resource management questions can be answered only with some combination of qualitative and quantitative data. These data could be obtained through two or more separate single-discipline projects, with an additional project to integrate the results. Depending on when, and how well, the separate

projects were planned, the integrated results may or may not respond precisely to the questions being asked. Another option would be to design a single integrated project from the start. The lessons of the projects presented in this chapter are that this latter option is worthwhile not only because it produces a set of rich and layered results that are more relevant, useful and adoptable at the level of the ultimate (farmer) beneficiary, but also because it ensures buy-in from varied stakeholders and has the added benefit of achieving high levels of researcher capacity-building and satisfaction.

We should not, however, be under any illusion that, simply because we are dealing with one project instead of several, a project integrating qualitative and quantitative approaches will be a cheaper or faster option. The costs are primarily in the form of more project meetings and capacity-building to ensure mutual methodological acceptance, the time needed for iteration of methods (particularly if some are seasonally constrained), and the intensive management required to keep a multidisciplinary (and usually multi-institutional) project on track. If we face up to these resource implications, then qualitative and quantitative approaches can be combined to great benefit.

Chapter Fourteen
Evaluating democracy assistance: the inadequacy of numbers and the promise of participation

GORDON CRAWFORD

Summary

Democracy assistance entails the promotion of democratization by international donor agencies. Over a decade after its introduction, evaluation of its impact and effectiveness has become crucial, yet faces considerable methodological challenges. In this chapter, the limitations of conventional evaluation methodologies are explored, notably those of the logical framework approach, with reference to recent evaluation studies in this field. Four main shortcomings are examined: a project rather than a programme focus; applicability to 'hard' rather than 'soft' data; inward rather than outward orientation; and a problematic emphasis on causality and quantitative indicators. An alternative methodology is proposed that involves a participatory political process. A participatory approach entails greater emphasis on qualitative methods, although quantitative methods can usefully be combined, for example by converting qualitative evidence into quantitative scores. Two advantages of the proposed methodology are claimed. For donor agencies, past and current efforts are subjected to more critical examination. For participant evaluators, knowledge of processes of political change is enhanced, strengthening local action for democratic reform. Thus the act of evaluation can become an act of democratization. Such arguments are at variance with current practice, however, and a wider aim of this chapter is to encourage a shift in development agency practice in evaluating democracy and governance assistance.

Introduction

During the 1990s, the promotion of democracy and governance (DG) emerged as a major field of activity within international development cooperation, with significant amounts of aid funding now allocated to this area. After more than a decade of such activities, the question of evaluation has become a crucial one, essential to assess the achievements of DG assistance as well as to learn lessons and improve its future effectiveness.

There are considerable challenges to evaluating DG assistance. This chapter examines the relative merits in this field of two competing methodological approaches: conventional evaluation and participatory evaluation. The chapter is in four main parts. First, this introduction briefly examines the challenges and problems associated with DG evaluation, notably in assessing the impact of external assistance on